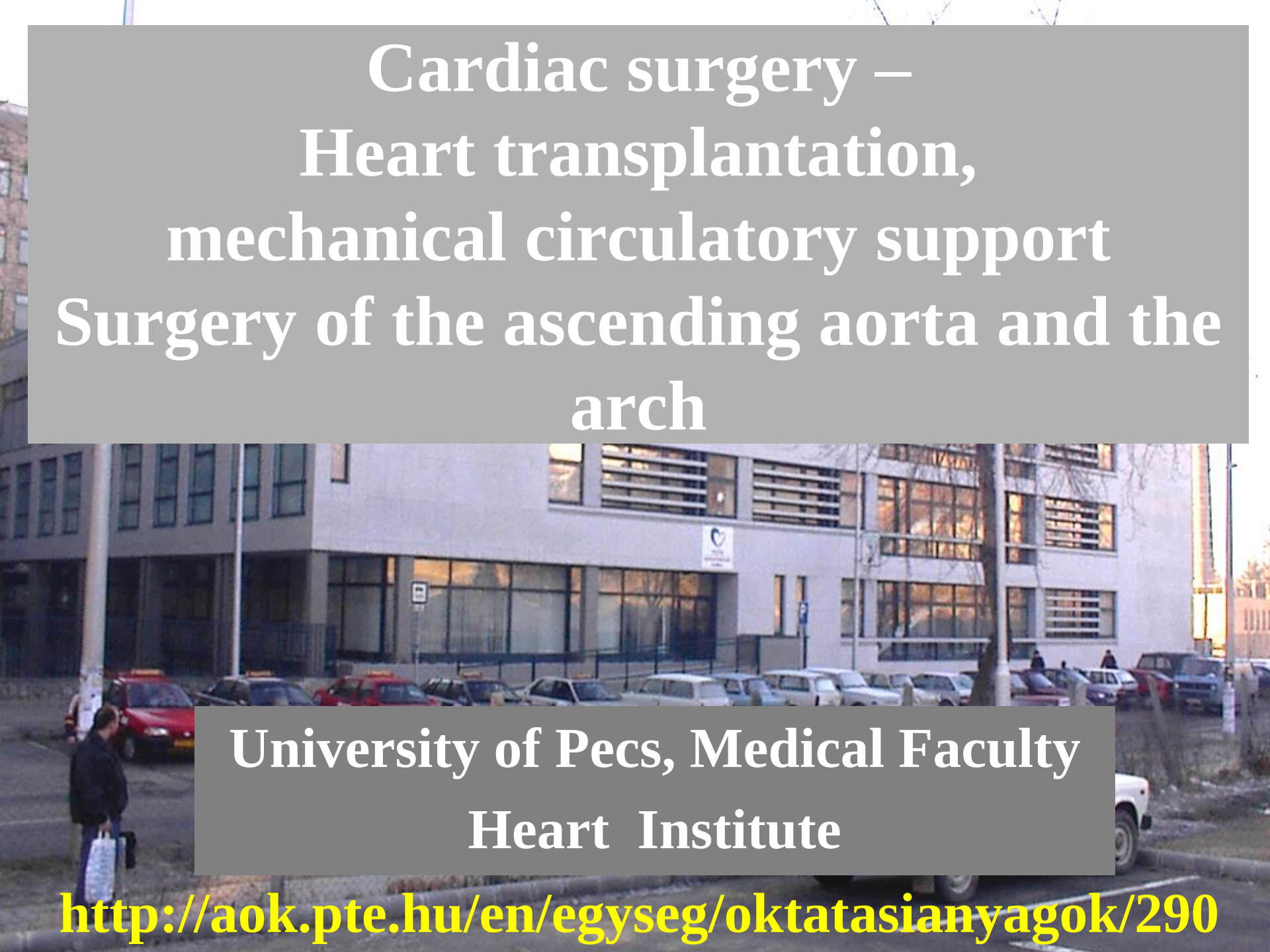
Cardiac surgery – Heart transplantation, mechanical circulatory support Surgery of the ascending aorta and the arch



University of Pecs, Medical Faculty

Heart Institute

http://aok.pte.hu/en/egyseg/oktatasianyagok/290

Treatment for heart failure

Medical:
inotrops, digitalis, diuretics, beta-blocker...

CRT, multisite pacing

Conventional surgical or interventional treatment of CAD, valvular disease

Acute mechanical circulatory support (<2 weeks)

Permanent mechanical circulatory support (>2 weeks)
„bridge to transplantation”, „bridge to recovery”, „bridge to bridge”, „destination therapy”

Heart transplantation

Mechanical circulatory support

Indication: serious reversible or irreversible heart failure in spite of maximal medical therapy

Aims:

Reversible: 1. assuring adequate tissue perfusion
2. unloading the heart until recovery

Irreversible: assuring adequate perfusion until HTX

Short range (<2 weeks) ⟷ Long-range (>2 weeks)

Extracorporal ⟷ Intracorporal

TAH ⟷ VAD (LVAD, RVAD, BiVAD)

Pulsatile ⟷ Continuous flow

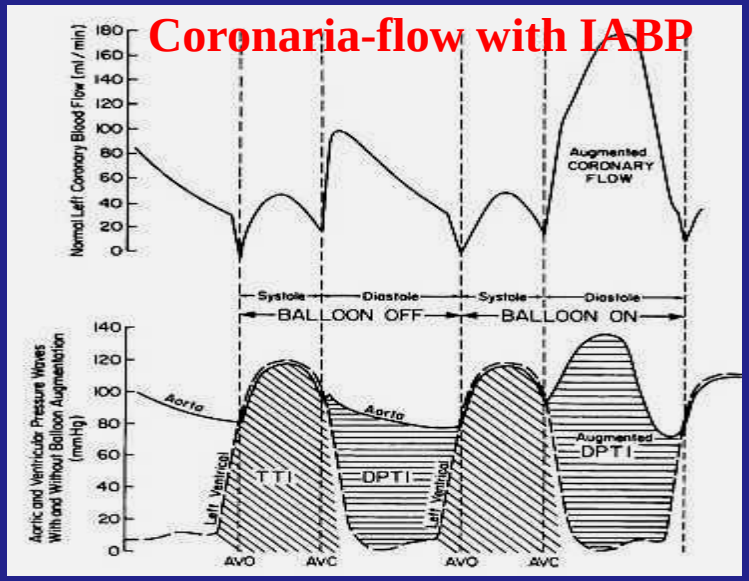
(TAH – total artificial heart, VAD – ventricular assist device)

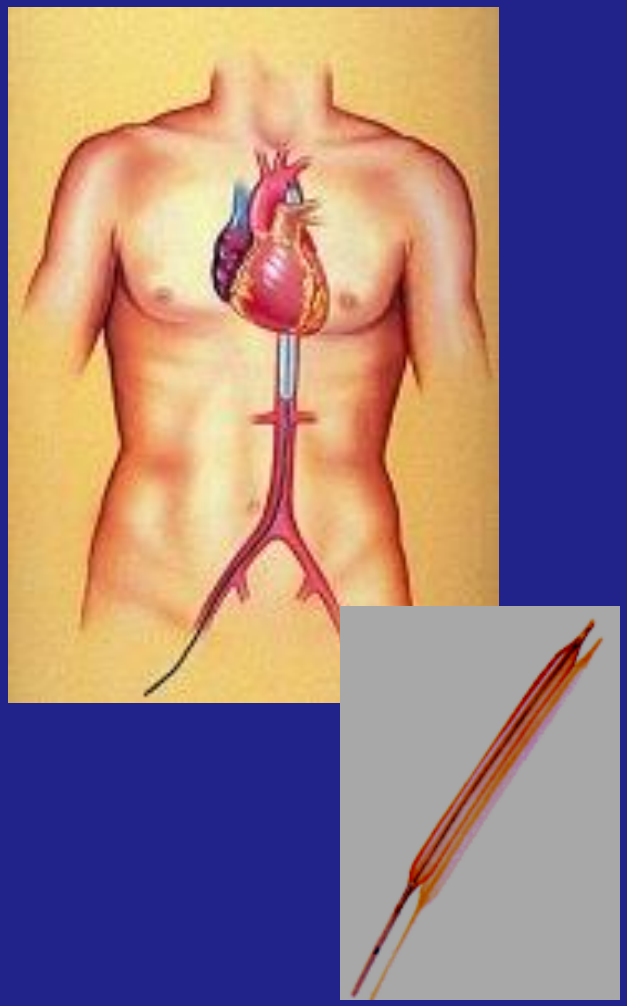
Acute mechanical circulatory support

Intraaortic balloon pump (IABP)

- failure of inotropic treatment
- threatening! cardiogenic shock

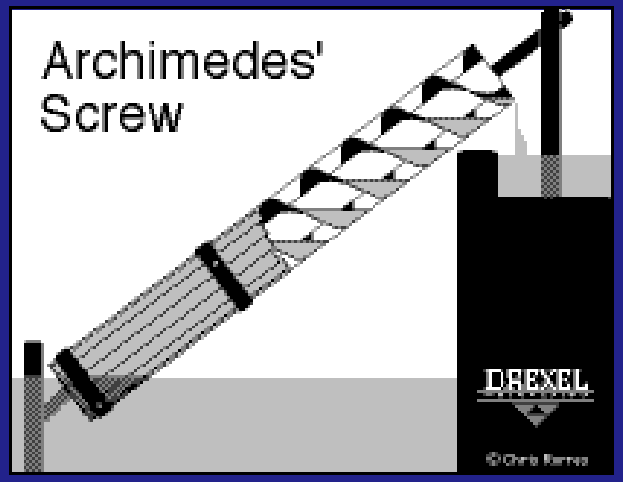
➢improving coronary perfusion
➢(reducing afterload)

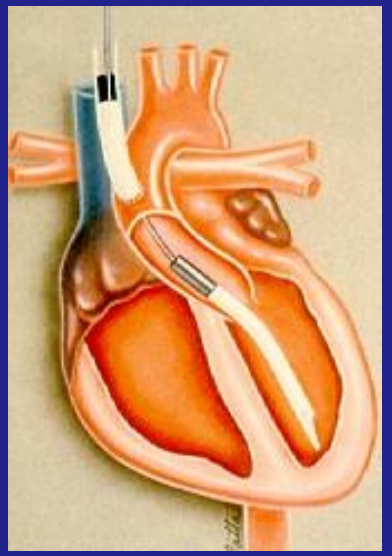




Acute mechanical circulatory support

Hemopump





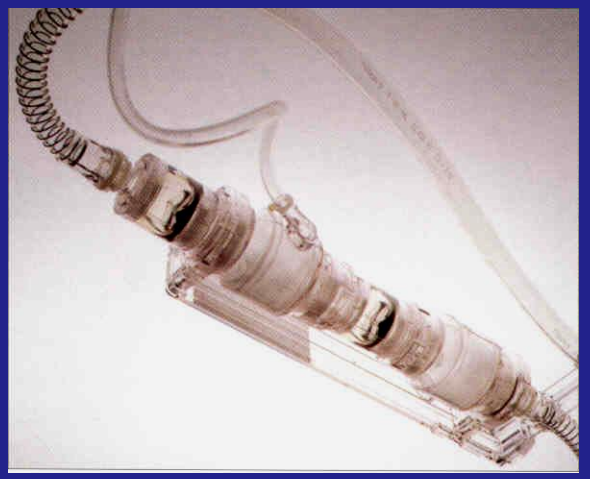
Hemopump device inserted into the left ventricle through the ascending aorta and the portable control unit.

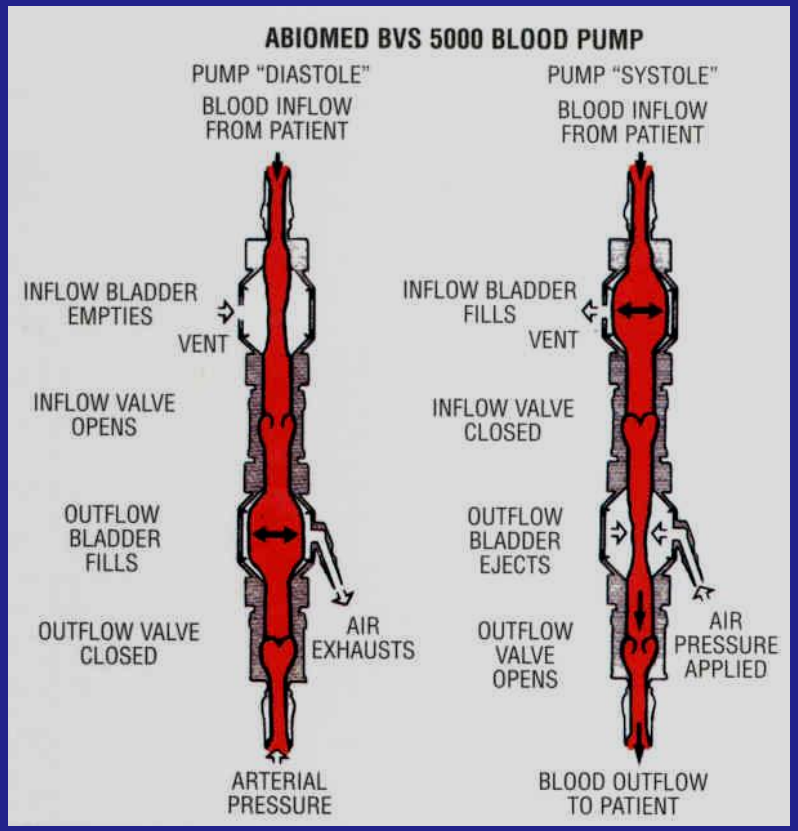
The 24-Fr version is capable to maintain the total minute volume, therefore the heart can be arrested medically without the background of ECC.

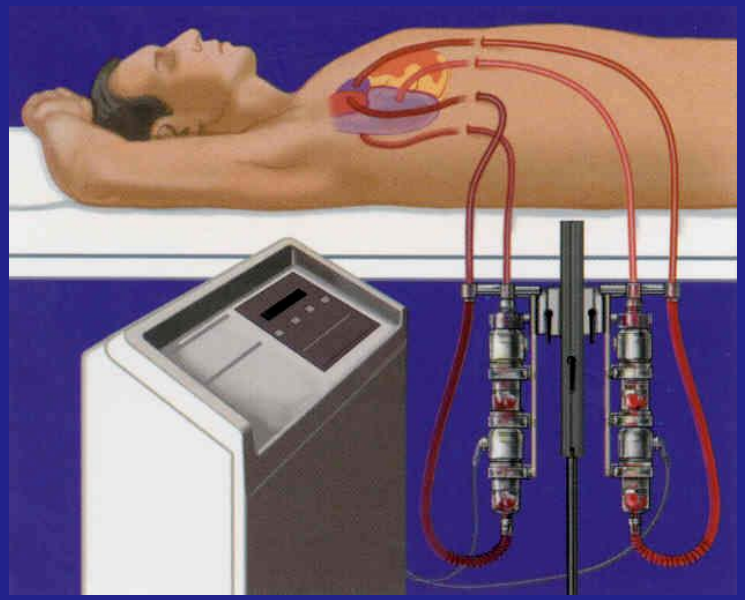
Acute mechanical circulatory support

Abiomed BVS 5000

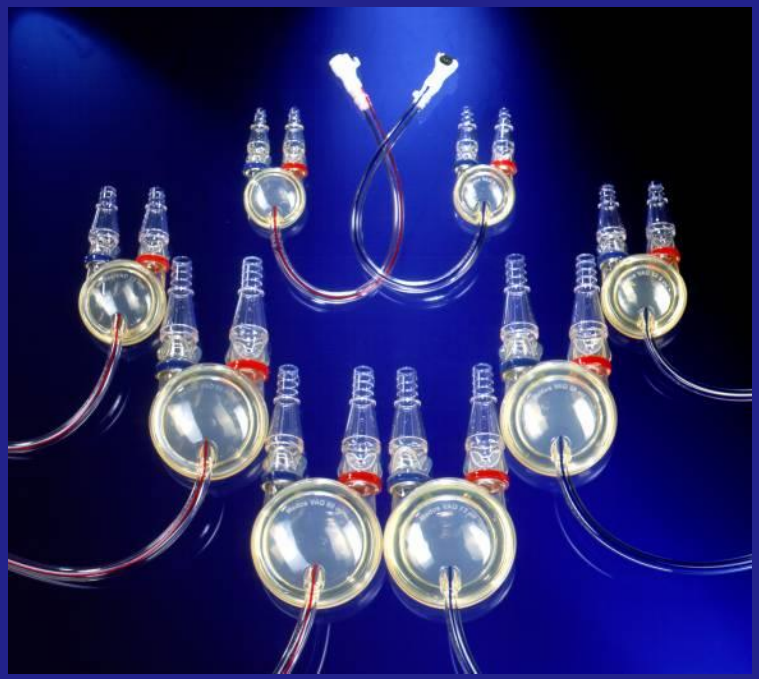
Univentricular or biventricular assist.







Mechanical circulatory support



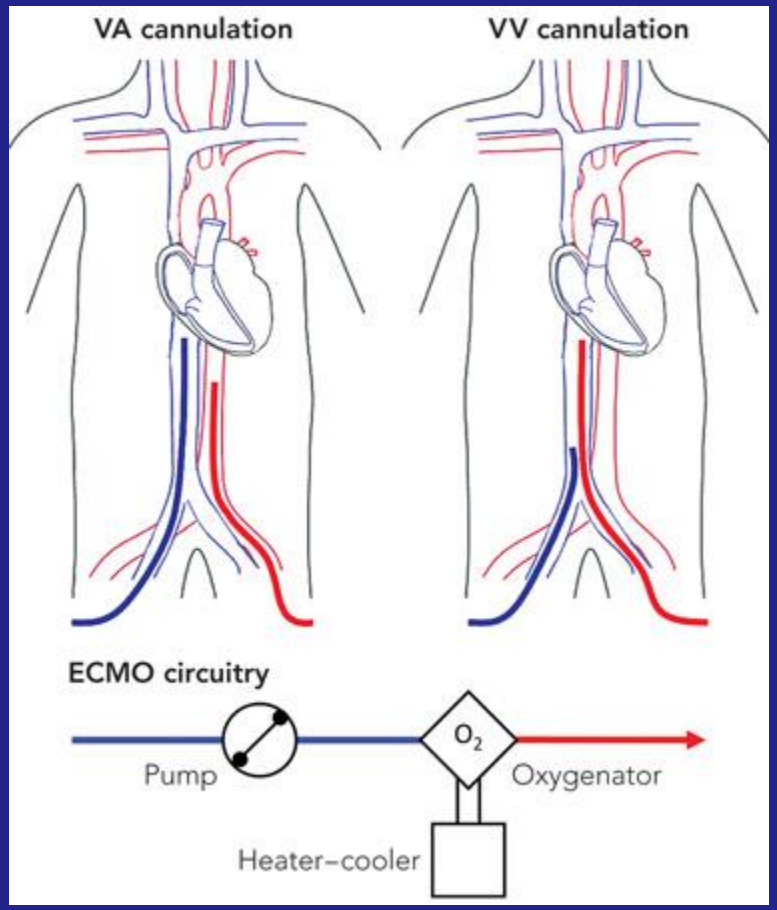
RVAD LVAD
BiVAD

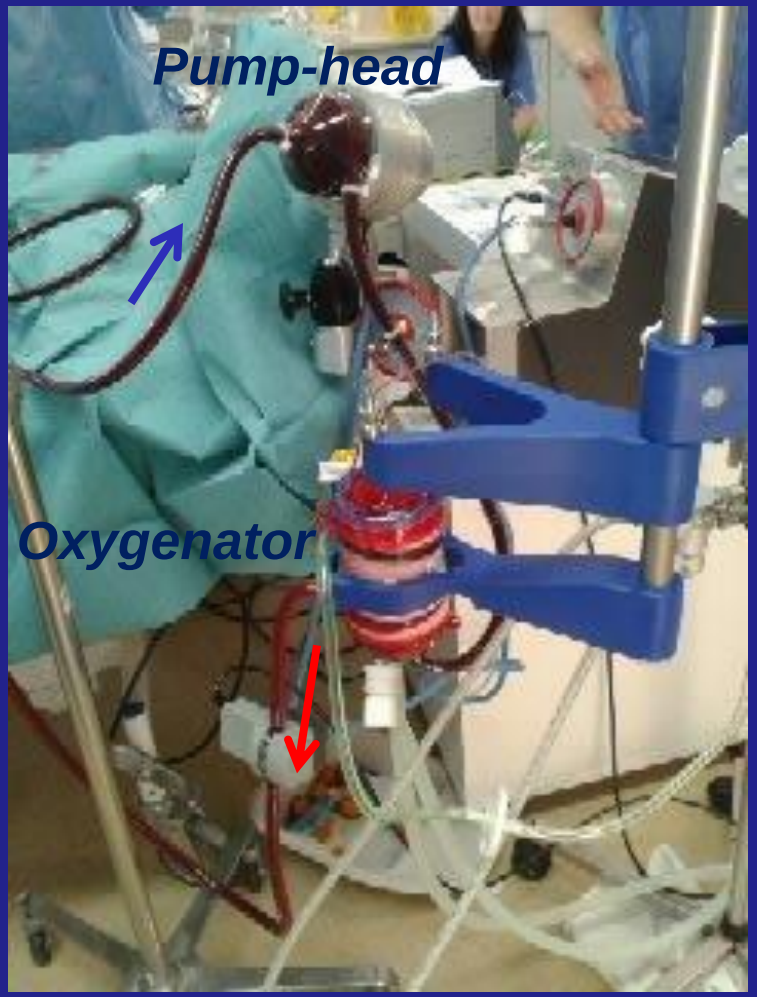
Pulsatile flow, paracorporal, mid-term

MEDOS
Medizintechnik AG

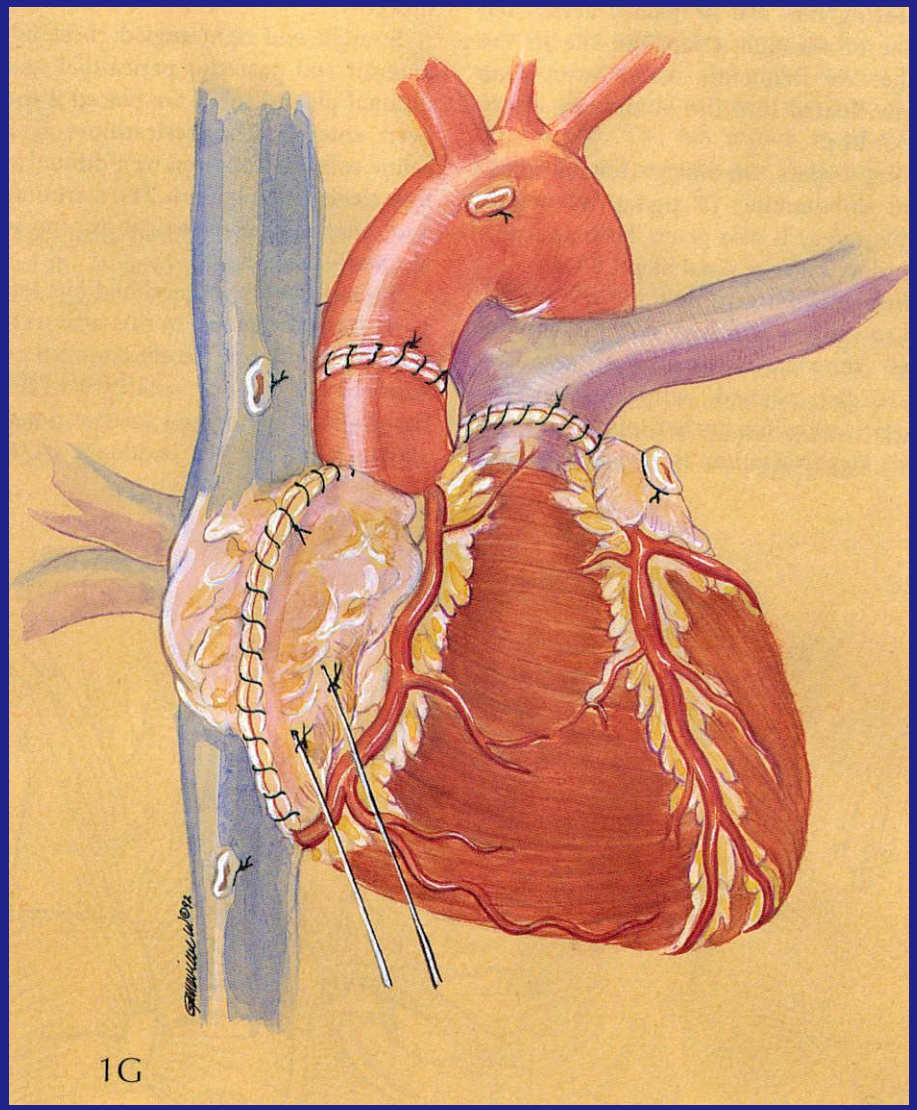
ECMO – extracorporal membrane oxygenator

Respiratory, cardiorespiratory insufficiency





The evolution of HTX



1905. Carrel, Guthrie

vascular suture, organ tx

1960. Lower, Shumway

present technique, cooling

1964. Hardy et al.

chimpanzee heart to human

1967. Barnard

human to human

1980s

cyclosporin

Admission to the HTX program

Indications:

- NYHA IV in spite of maximal iv inotrop therapy
- **Max. VO2 < 10ml/kg/min** (<14, relative indic.)
- syncope, ventricular ectopies
- bad quality of life, complaints limiting everyday activity
- high risk for cardiac mortality within 1 year

Contraindications:

- > 60-65 years
- active infection, or GI ulcer, diabetes mellitus, serious peripheral vascular disease, pulmonary disease, malignancy
- **elevated pulmonary vascular resistance** (>5 Wood, >3.5 rel)
- psychical instability, alcohol or drug abuse
- loss of compliance, impossible follow-up

Donor selection

- brain death
- matching ABO with the recipient
- age less than 40-45 years
- similar body weight (size) to the recipient
- loss of cardiovascular disease
- loss of pulmonary disease
- no malignancy (except brain tumor)
- no infection (HIV, CMV, Hepatitis)
- no sepsis
- expected ischemic time < 4-6 hours

Immunosuppression after HTX

- **MMF (mycophenolate mofetil, *Cellcept*)**
- **tacrolimus (calcineurine inhibitor)**
- **corticosteroid (prednisolone)**
- **/cyclosporine (earlier)/**

Rejection:

- **corticosteroid**
- **ATG (anti-thymocyte-globuline)**
- **ALG (anti-lymphocyte-globuline)**

Regular endomyocardial biopsy

Special complications of HTX

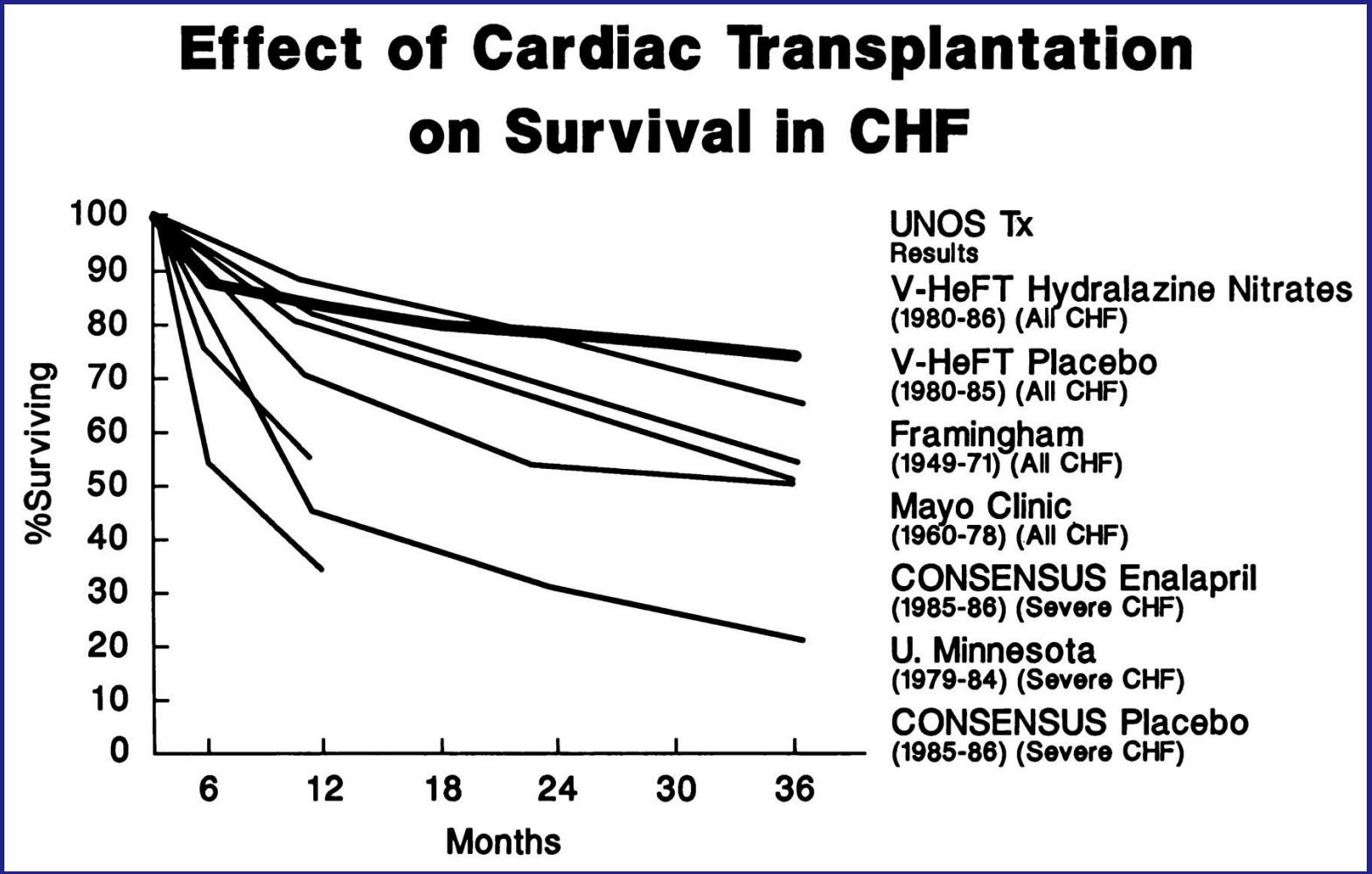
- infection (transmission, susceptibility)
- rejection
- graft coronariasclerosis
- secondary malignancies (lymphomas)
- nefrotoxicity (of cyclosporin)
- death

Problems of HTX

- complications → new immunosuppressives
- donor shortage → networks (UNOS, Eurotransplant), alternatives
- ethical concerns (abating)
- legal concerns (abating)
  (definition of brain death, need for consent)
- expenses

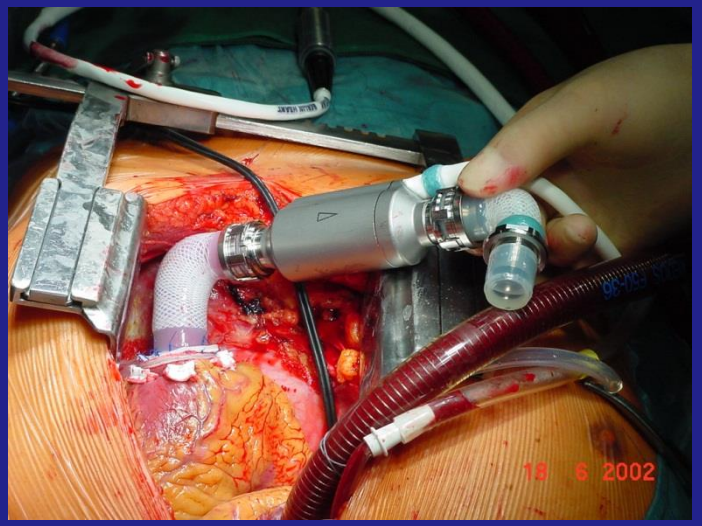
90 % one-year and 50 % 10-year survival, annually about 3500 HTX all over the word, whereas emerging need for several ten-thousand

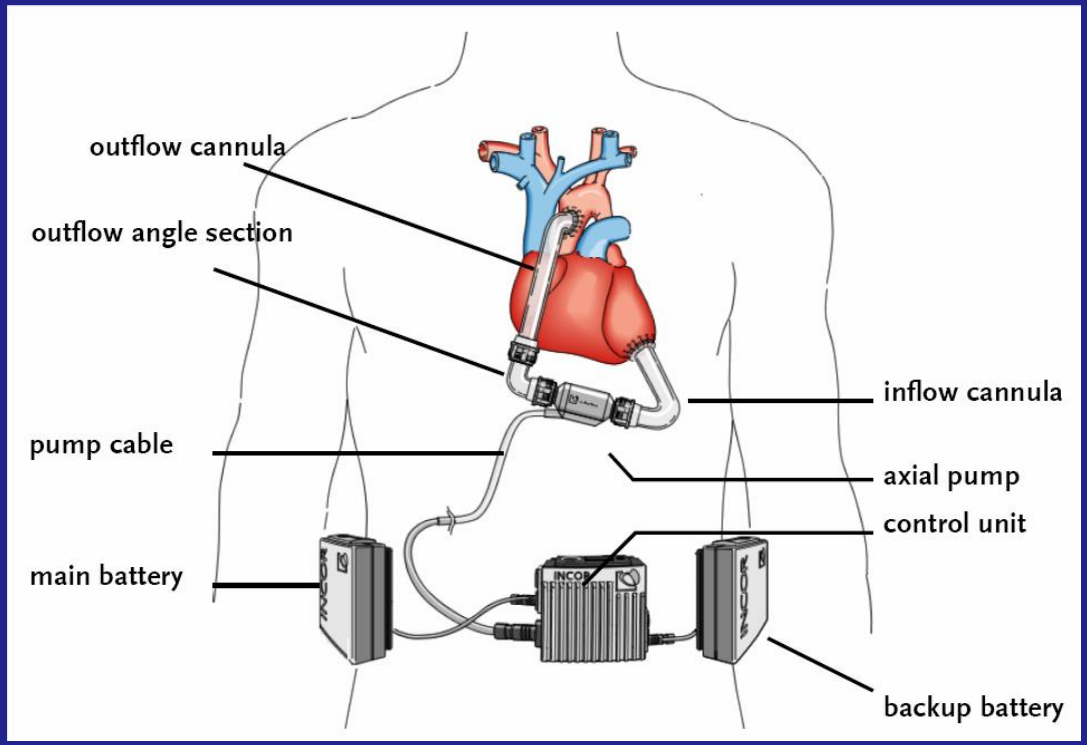
Comparing survival after HTX or medical treatment

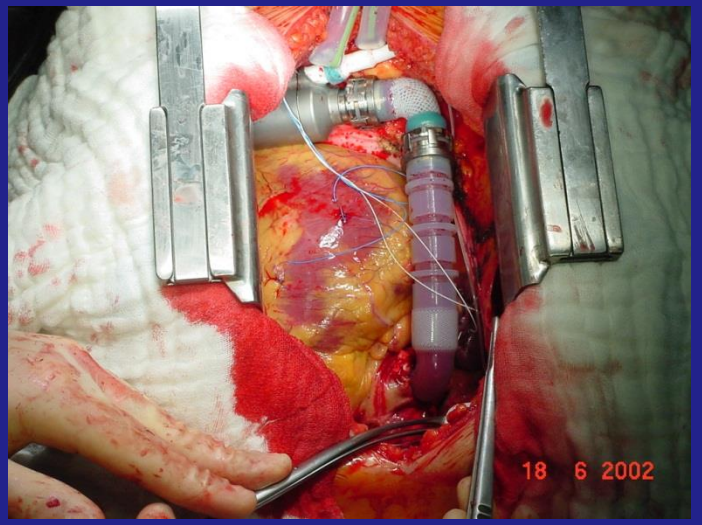


Berlin Heart Incor (LVAD)

- Intracorporal, continuous flow, permanent
- INR: 2,8-3,2
- APTI: 70-90 s
- Efficient anti-TCT therapy

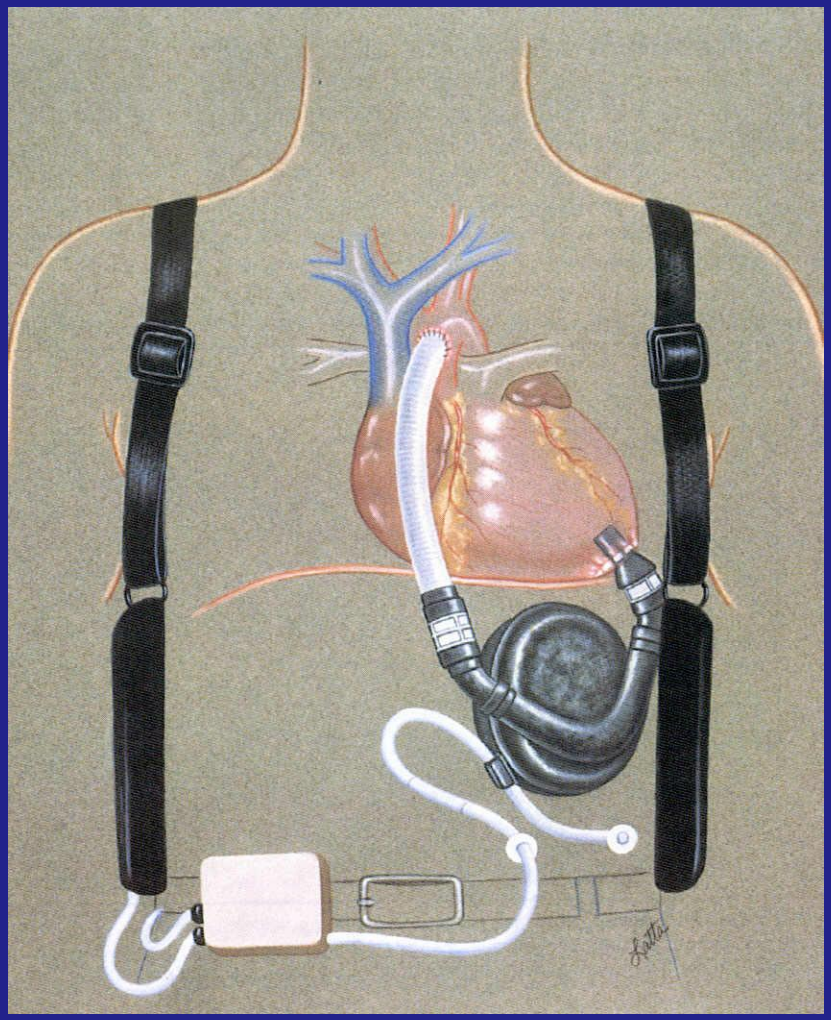


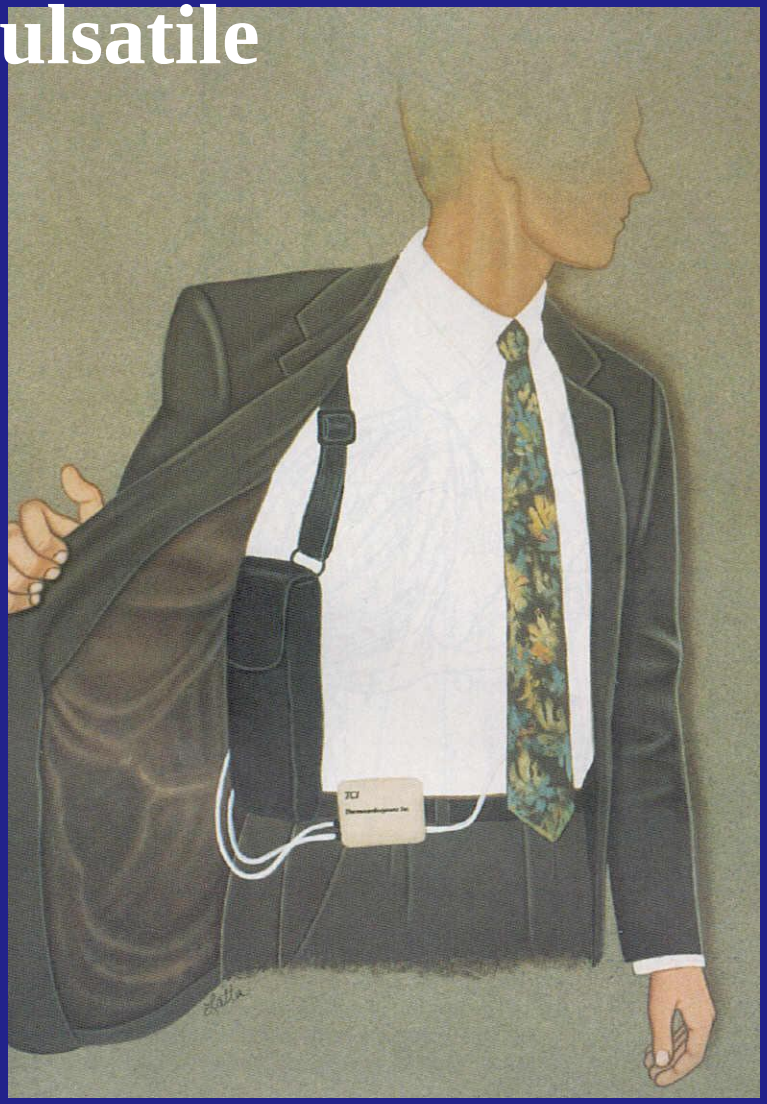




Mechanical circulatory support - Univentricular assist

Intracorporal, long-term, pulsatile





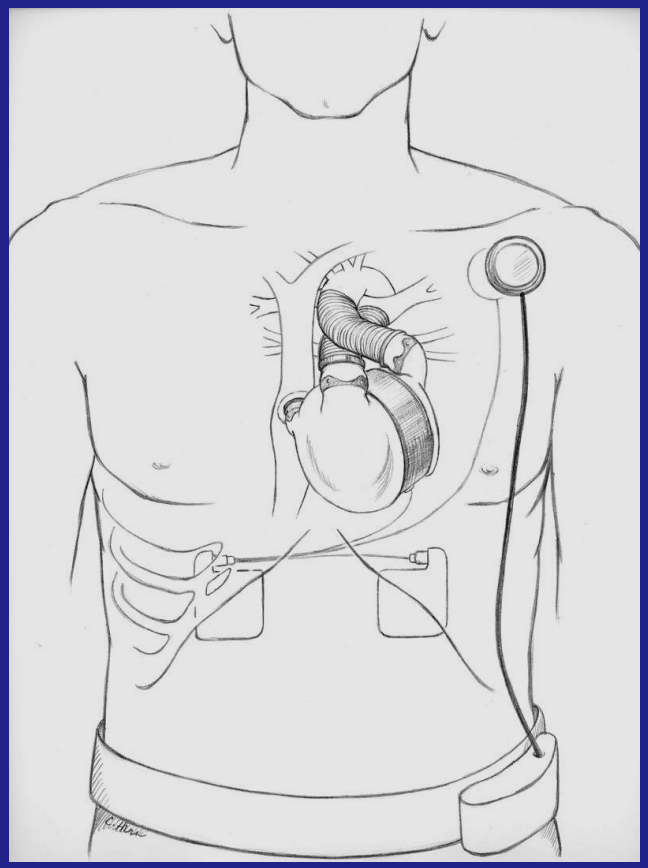
Mechanical circulatory support - Univentricular assist

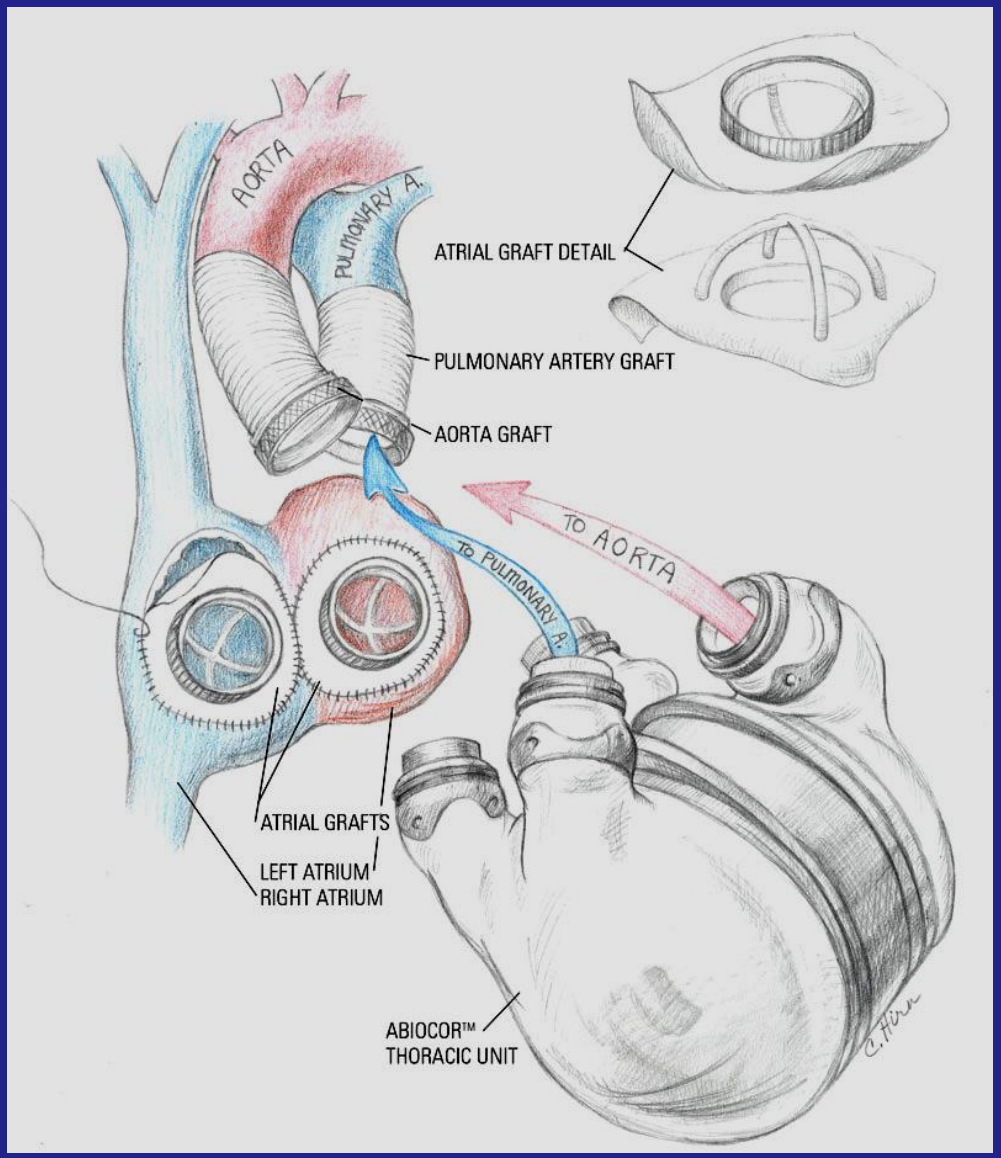
1963. M. DeBakey – first human application

Draining blood from the apex of the left ventricle, pumped into the ascending or descending aorta. (applicable also in the right heart)
Since the 80s mainly in the US several hundred devices were implanted as a bridge to transplantation. Recognized the reverse remodeling as an effect of unloading the heart. Many patients were removed from HTX program because of their improvement. The future?

Artificial heart – the Abiocor

Artificial heart – the Abiocor





Artificial heart, xenotransplantation

<u>Artificial heart</u>: human application in experimental phase

1959. S. H. Norton, T. Akutsu, W. Kolff

1969. D. A. Cooley (Liotta pneumatic heart) as a bridge to transplantation

1982. DeVries (Jarvik-7) as a final therapy

***Now:* Texas (Abiocor), Cleveland, Pittsburg**

***Problems:* thromboembolism, power supply, safety of operation, infection, haemolysis, adaptation to needs**

<u>Xenotransplantation</u>: animal experiments (swine)

Preventing rejection with modified surface antigenes

Future possibilities

Molecular cardiomyoplasty: Fibroblasts in the infarction scar are "infected" with MyoD-gene resulted in muscular differentiation.

Cellular cardiomyoplasty: infiltrating the scar with myoblasts (satellite-cells) or stem cells from skeletal muscle, those can differentiate into heart muscle

Embryonal correction of the gene responsible for the cardiomyopathy

Induction of angioneogenesis by growth factors

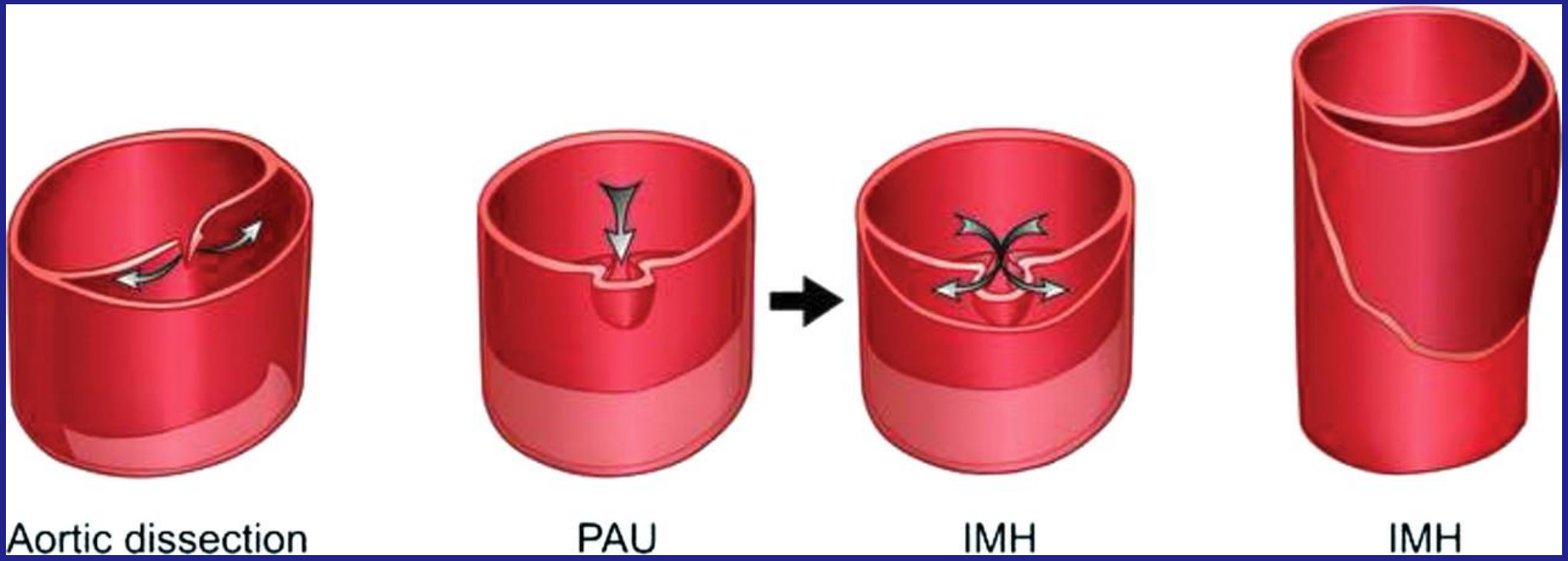
Summary

- HTX – gold standard
- Efficient mechanical circulatory support avail.
- The timing of mechanical assist is crucial !
- Choosing the appropriate device (availabilities)
- Bridge to HTX reduces mortality and costs
- Fast technical development – future ?
- Expenses

Aortic diseases

- Atherosclerosis
- Aneurysm (saccular, fusiform, ≥150% normal diam.)
- Dissection: intimal tear, flap, helical pseudo lumen (acute<2weeks, subacute, chronic>6weeks)
- Transsection (traumatic, due to deceleration, prox. DA, dist. AA)
- Rupture: bleeding to mediastinum, bronchi, pleura, pericardium (tamponade!)
- Aortitis (S. aureus, Salmonella, syphilis, Takayashu, Giant cell)
- Penetrating atherosclerotic ulcer (PAU)
- Intramural haematoma (IMH, from vasa vasorum)
- Acute aortic syndrome (acute dissection, PAU, IMH)
- Aortic regurg. (annular dilation, rupture, dissection)

Acute Aortic Syndrome



Acute aortic dissection

- 2-3.5 cases/100 000 persons/year
- Symptoms: chest pain, horsness, focal ischaemia, bleeding, hypovolaemia, shock, tamponade, AI→pulm. Edema, embol.
- Diagnosis: Echo, CT, MRI, TEE, D-dimer (?!)
- Spontaneous mortality:

  asc. included: 35% at 1 day, 50% at 2 days, 70% at 1 week

  desc.: 90% survival at 1 month
- Treatment:

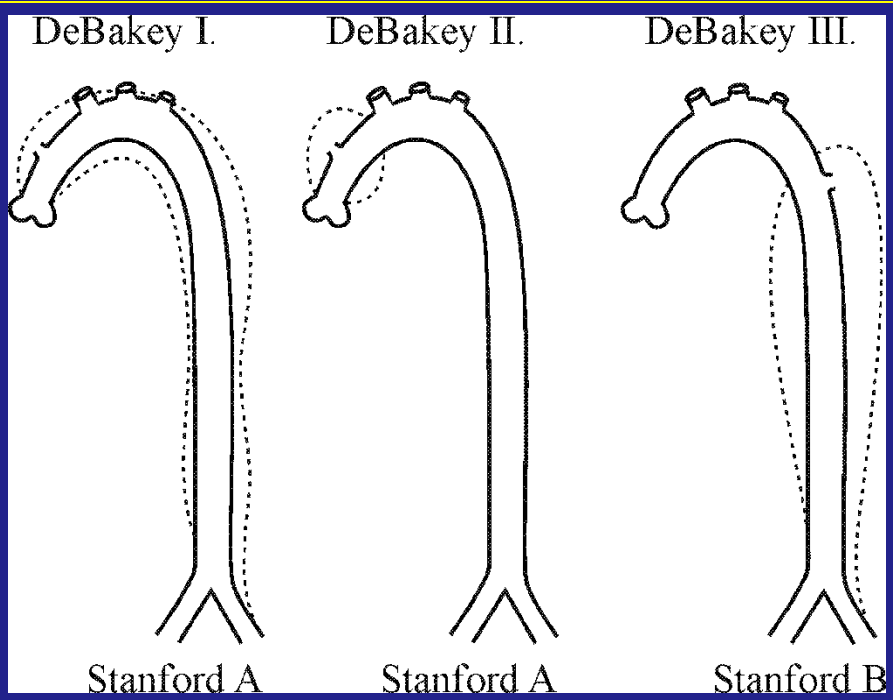
  initial medical: (dP/dt↓, SBP<100-120mmHg, pulse:60-80/min)

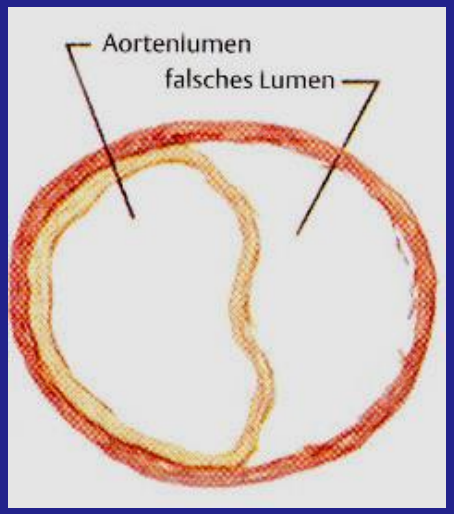
  β-blocker, nitrate, opiate

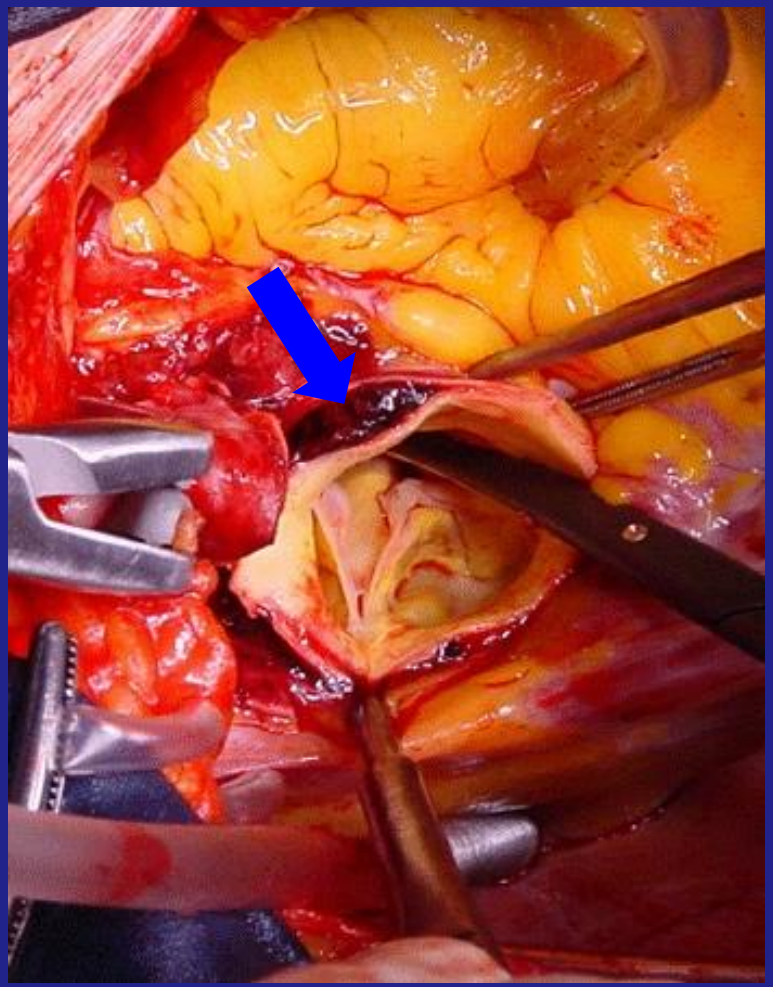
  acute ascending – emergency operation

  desc – medical treatment unless ischaemic signs occur

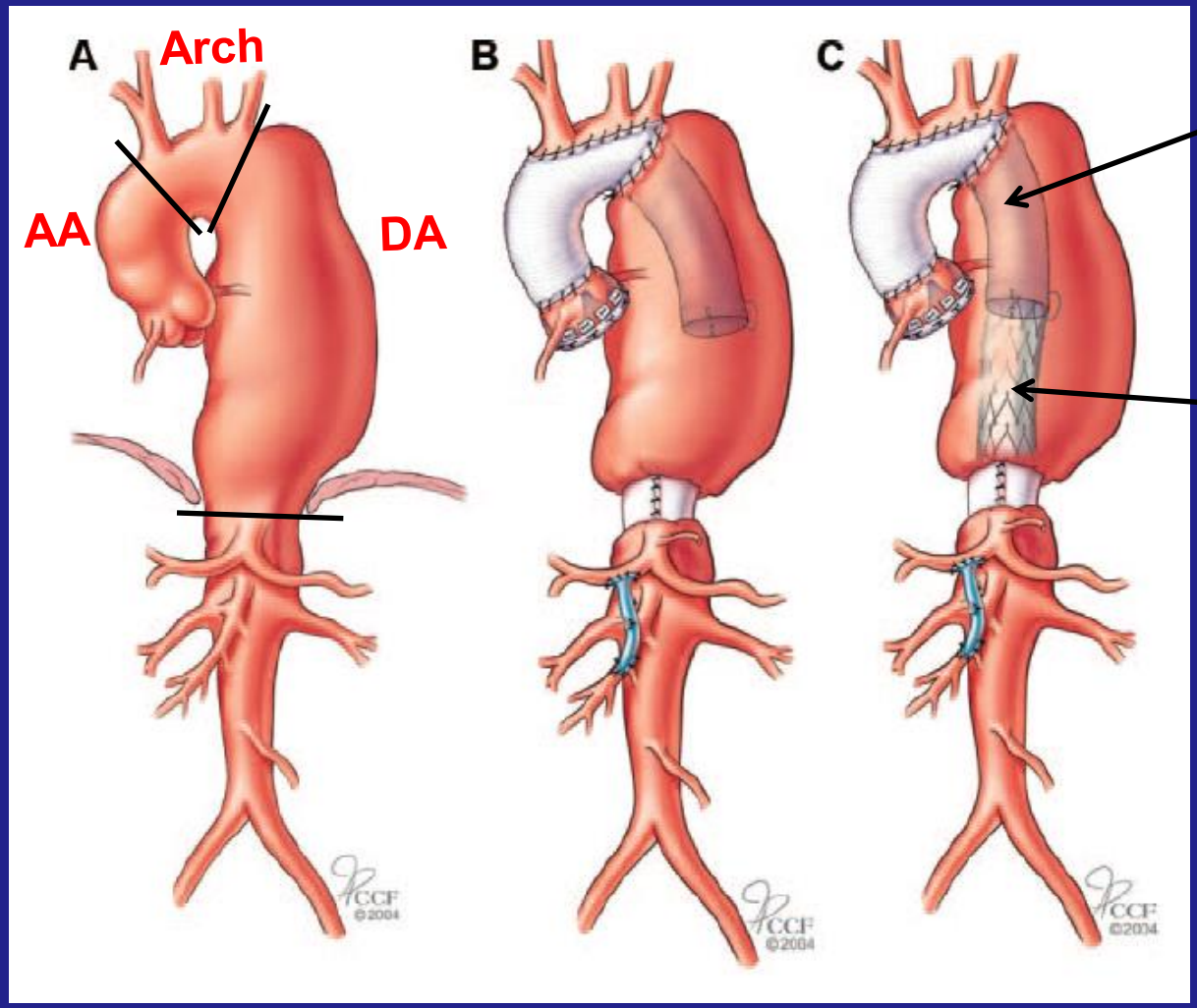
Aortic dissection







Extensive aortic aneurysm



Recommendations for Asymptomatic Patients With Ascending Aortic Aneurysm

1. Asymptomatic patients with degenerative thoracic aneurysm, chronic aortic dissection, intramural hematoma, penetrating atherosclerotic ulcer, mycotic aneurysm, or pseudoaneurysm, who are otherwise suitable candidates and for whom the ascending aorta or aortic sinus diameter is **5.5 cm** or greater should be evaluated for surgery

2. Patients with Marfan syndrome or other genetically mediated disorders (vascular Ehlers-Danlos syndrome, Turner syndrome, bicuspid aortic valve, or familial thoracic aortic aneurysm and dissection) should undergo elective operation at smaller diameters (**4.0 to 5.0 cm** depending on the condition; see Section 5) to avoid acute dissection or rupture.

3. Patients with a growth rate of more than **0.5 cm/y** in an aorta that is less than 5.5 cm in diameter should be considered for operation.

4. Patients undergoing aortic valve repair or replacement and who have an ascending aorta or aortic root of greater than **4.5 cm** should be considered for concomitant repair of the aortic root or replacement of the ascending aorta.

Recommendation for Symptomatic Patients With Thoracic Aortic Aneurysm

1. Patients with symptoms suggestive of expansion of a thoracic aneurysm should be evaluated for prompt surgical intervention unless life expectancy from comorbid conditions is limited or quality of life is substantially impaired

- **TEE (semiinvasive)**
- **CT (ECG-gated)**
- **MRI (ECG gated)**

Recommendations for Aortic Arch Aneurysms

1. For thoracic aortic aneurysms also involving the proximal aortic arch, partial arch replacement together with ascending aorta repair using right subclavian/ axillary artery inflow and hypothermic circulatory arrest is reasonable.

2. Replacement of the entire aortic arch is reasonable for acute dissection when the arch is aneurysmal or there is extensive aortic arch destruction and leakage.

3. Replacement of the entire aortic arch is reasonable for aneurysms of the entire arch, for chronic dissection when the arch is enlarged, and for distal arch aneurysms that also involve the proximal descending thoracic aorta, usually with the elephant trunk procedure.

4. For patients with low operative risk in whom an isolated degenerative or atherosclerotic aneurysm of the aortic arch is present, operative treatment is reasonable for asymptomatic patients when the diameter of the arch exceeds **5.5 cm**.

5. For patients with isolated aortic arch aneurysms **less than 4.0 cm** in diameter, it is reasonable to reimage using computed tomographic imaging or magnetic resonance imaging, at **12-month** intervals, to detect enlargement of the aneurysm.

6. For patients with isolated aortic arch aneurysms **4.0 cm or greate**r in diameter, it is reasonable to reimage using computed tomographic imaging or magnetic resonance imaging, at **6-month** intervals, to detect enlargement of the aneurysm.

Recommendations for Descending Thoracic Aorta and Thoracoabdominal Aortic Aneurysms

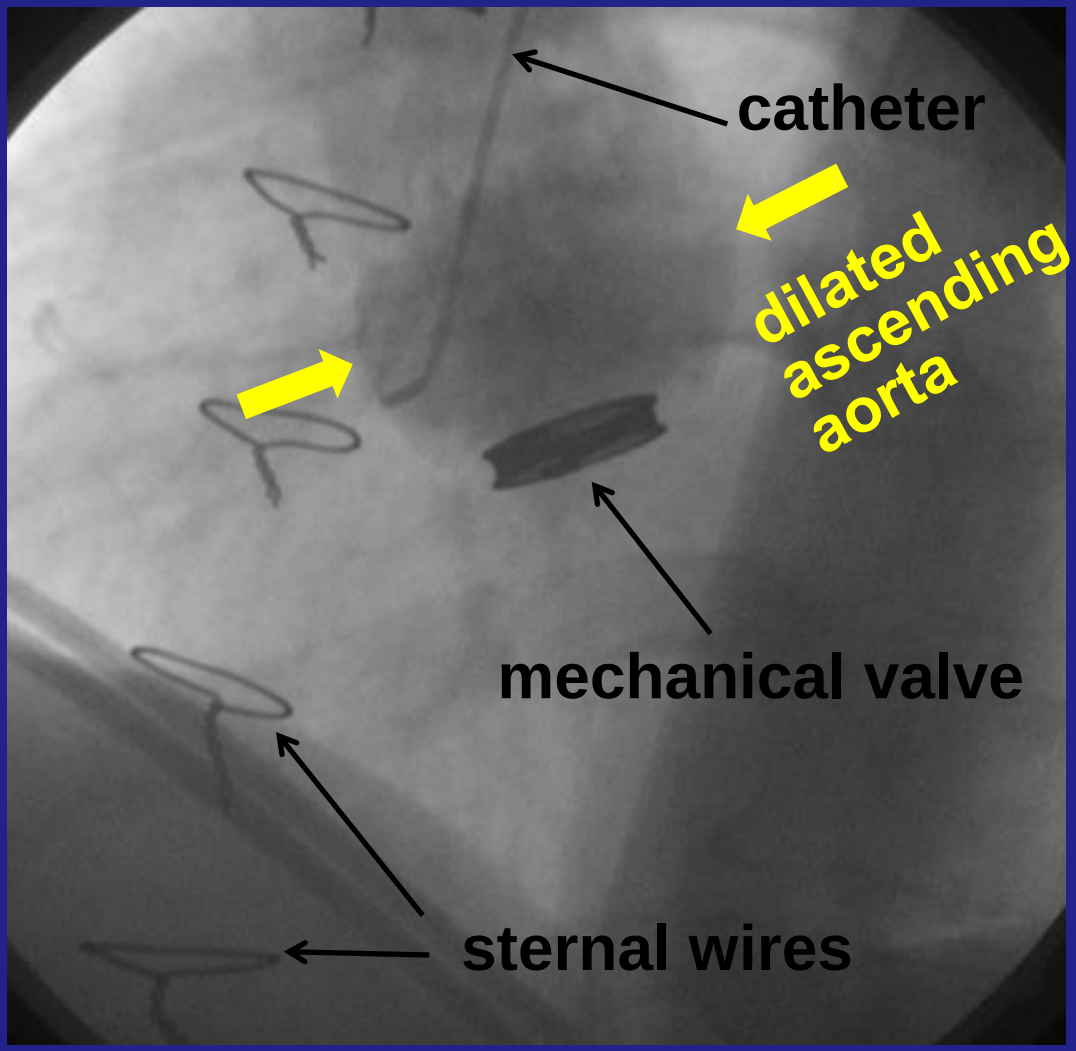
1. For patients with chronic dissection, particularly if associated with a connective tissue disorder, but without significant comorbid disease, and a descending thoracic aortic diameter exceeding **5.5 cm**, **open repair** is recommended.

2. For patients with degenerative or traumatic aneurysms of the descending thoracic aorta exceeding **5.5 cm**, saccular aneurysms, or postoperative pseudoaneurysms, **endovascular stent grafting** should be strongly considered when feasible.

3. For patients with thoracoabdominal aneurysms, in whom endovascular stent graft options are limited and surgical morbidity is elevated, elective surgery is recommended if the aortic diameter exceeds **6.0 cm**, or less if a connective tissue disorder such as Marfan or Loeys- Dietz syndrome is present.

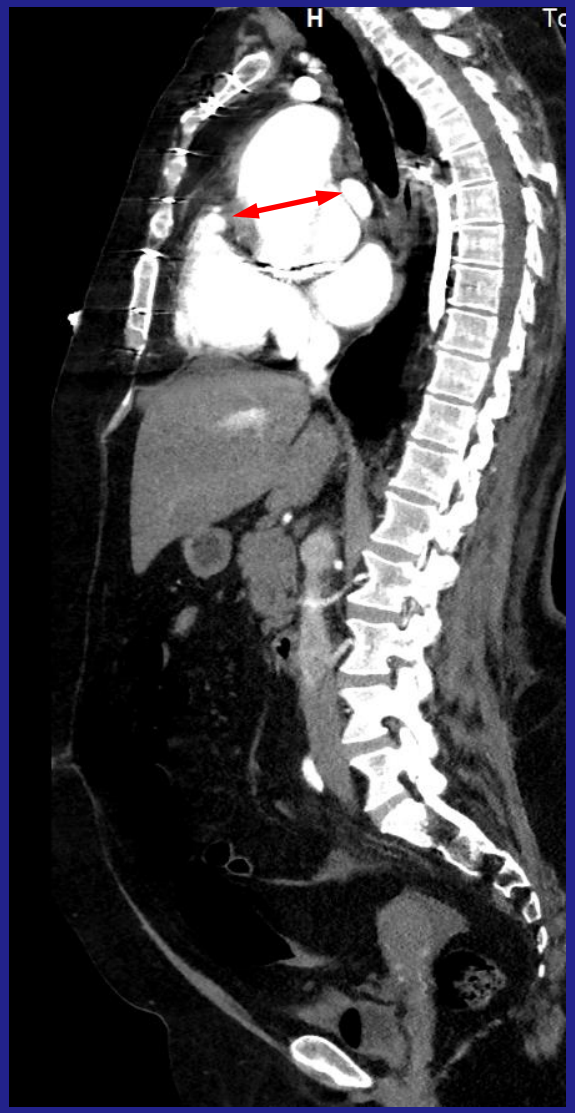
4. For patients with thoracoabdominal aneurysms and with end-organ ischemia or significant stenosis from atherosclerotic visceral artery disease, an additional revascularization procedure is recommended.

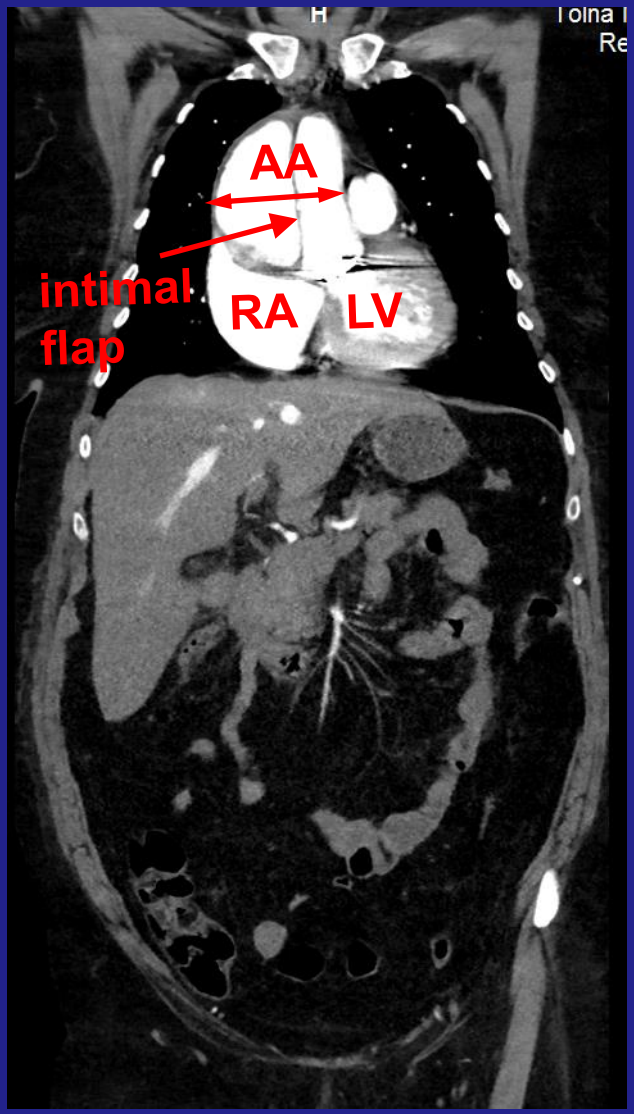
Dilated ascending aorta with artef. valve



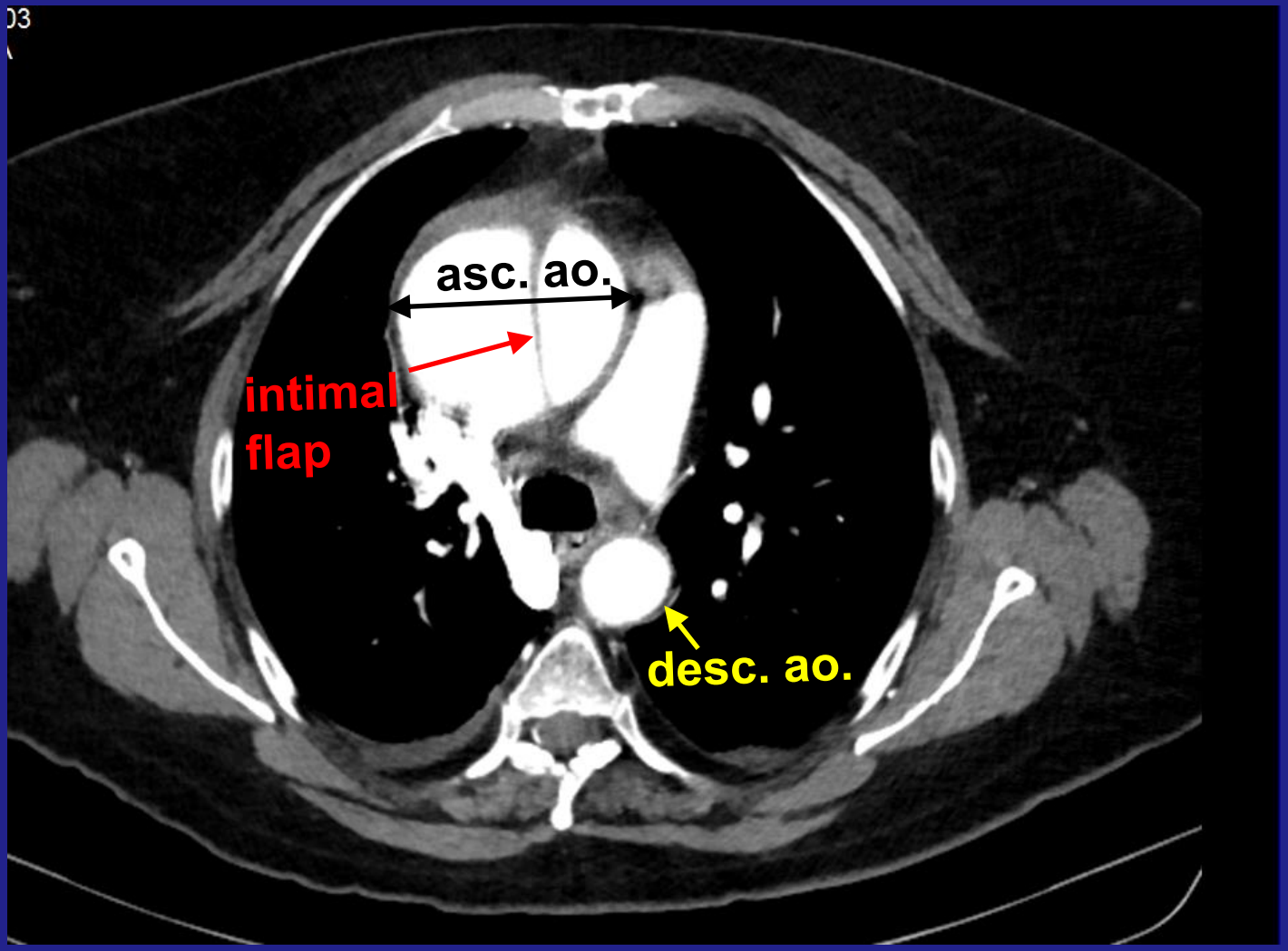
Aortogram

Chronic dissection on ascending aorta



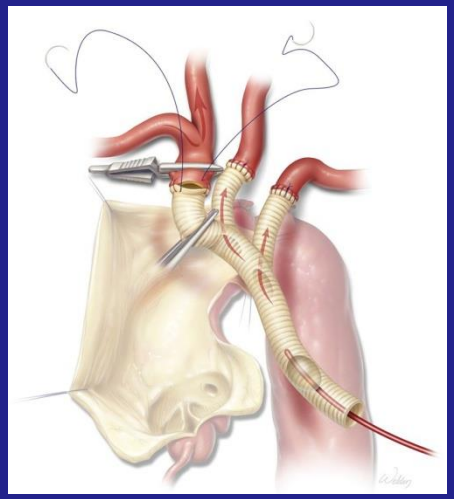


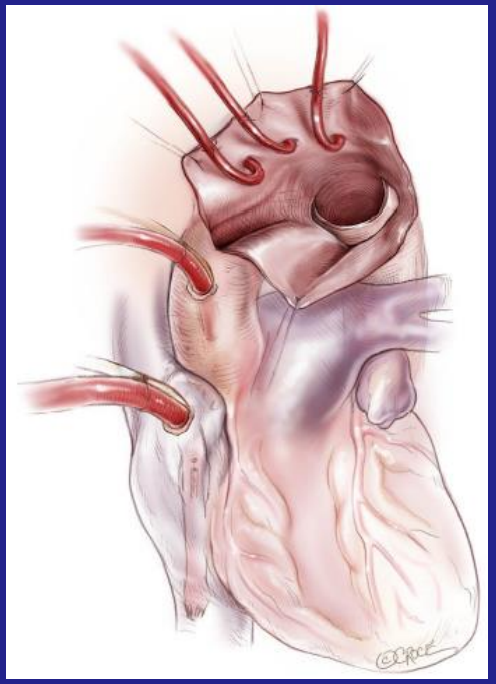
Chronic dissection on ascending aorta



Hypothermia, cerebral protection

- Extracorporal circulation (heparinization)
- Decreasing metabolic demand by cooling (profound≤14°C, deep≤20°C, moderate ≤28°C, mild ≤34°C hypothermia)
- Circulatory arrest (at 20°C: 30-40 min)
- Selective brain perfusion (**ante**, retro)
- Selective visceral perfusion (thoracoabd.)
- Ice around the head
- Deep anaesthesia, barbiturate
- Room temperature set at 20°C

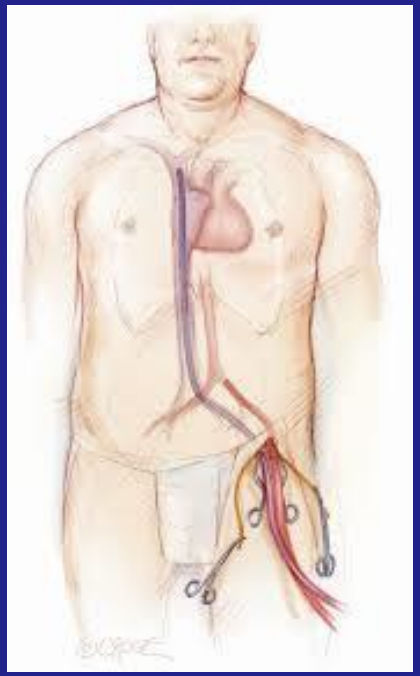




Cannulation techniques

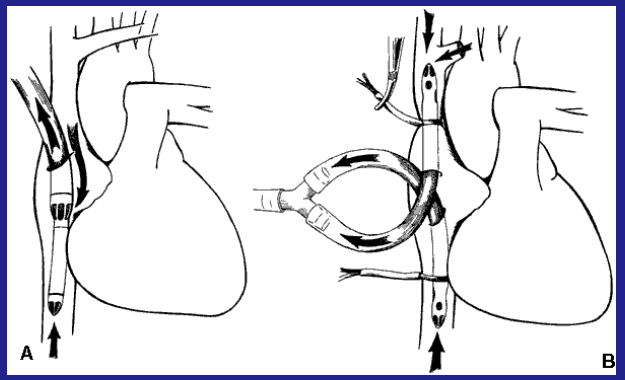
Arterial access:

- Ascending aorta
- Anonymous artery
- Proximal arch
- Axillary artery
- Femoral artery
- Carotid artery
- Vascular graft
- Lig. arteriosum
- Any other…

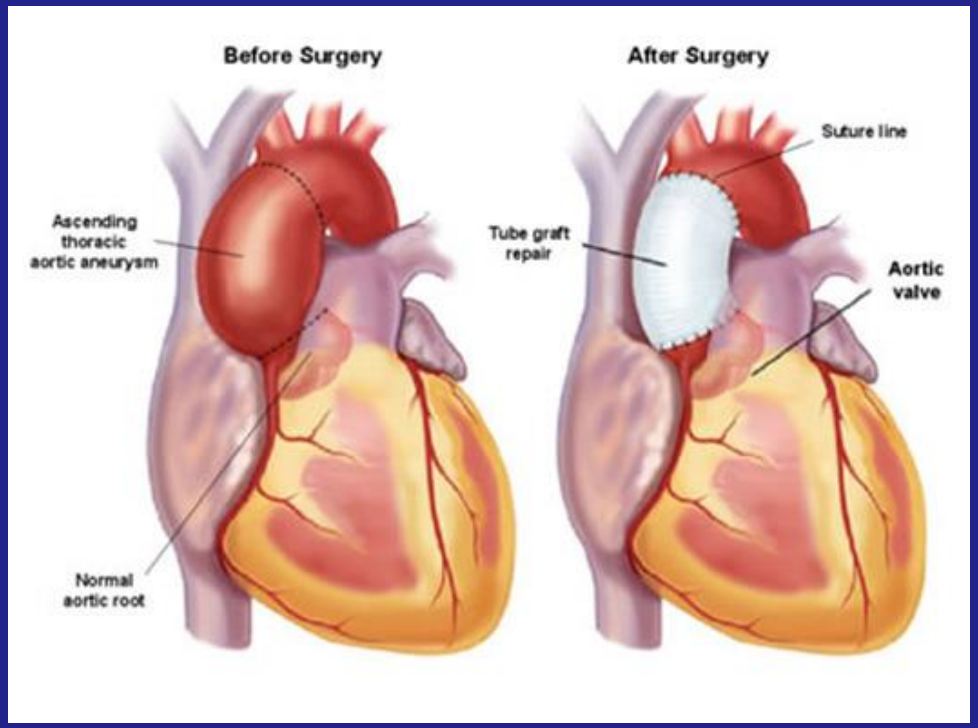


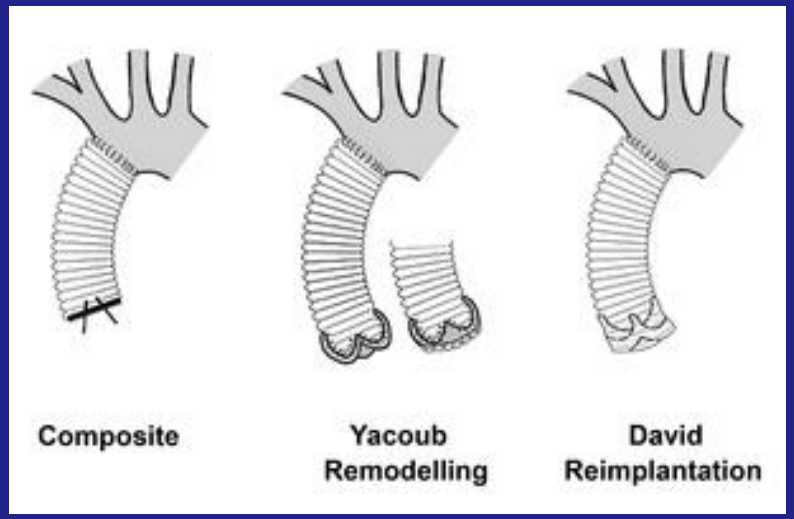
Venous access:

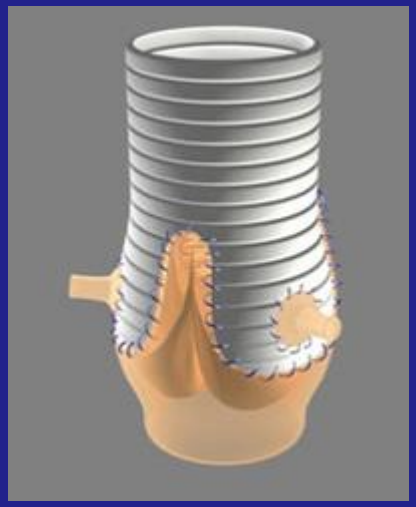
- Right atrium
  - -two stage
  - -bicaval
- Femoral vein

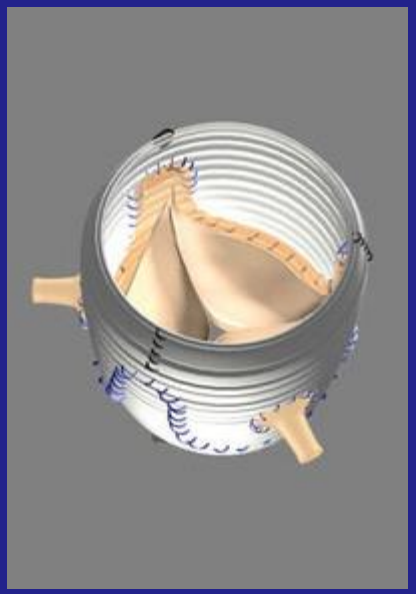


Isolated ascending, valve sparing





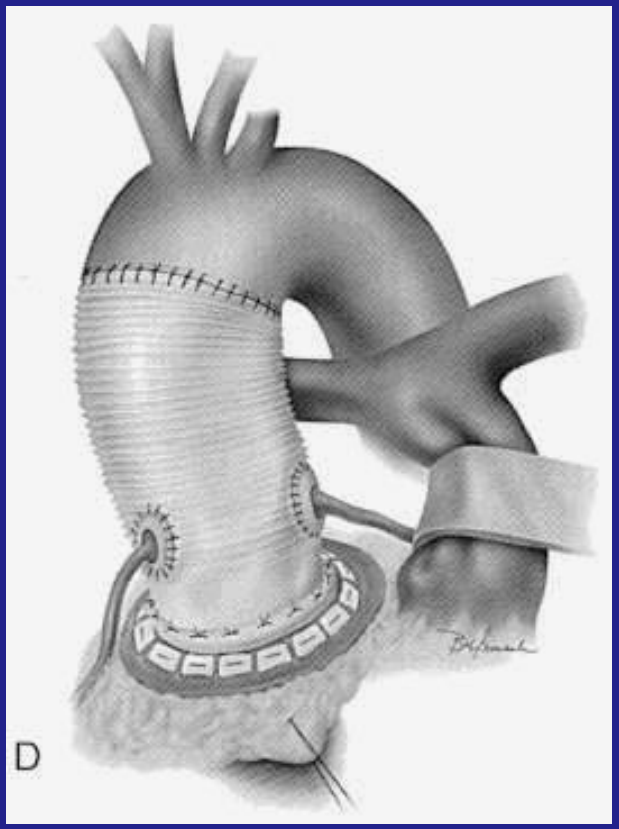




Bentall-procedure (valve+graft)

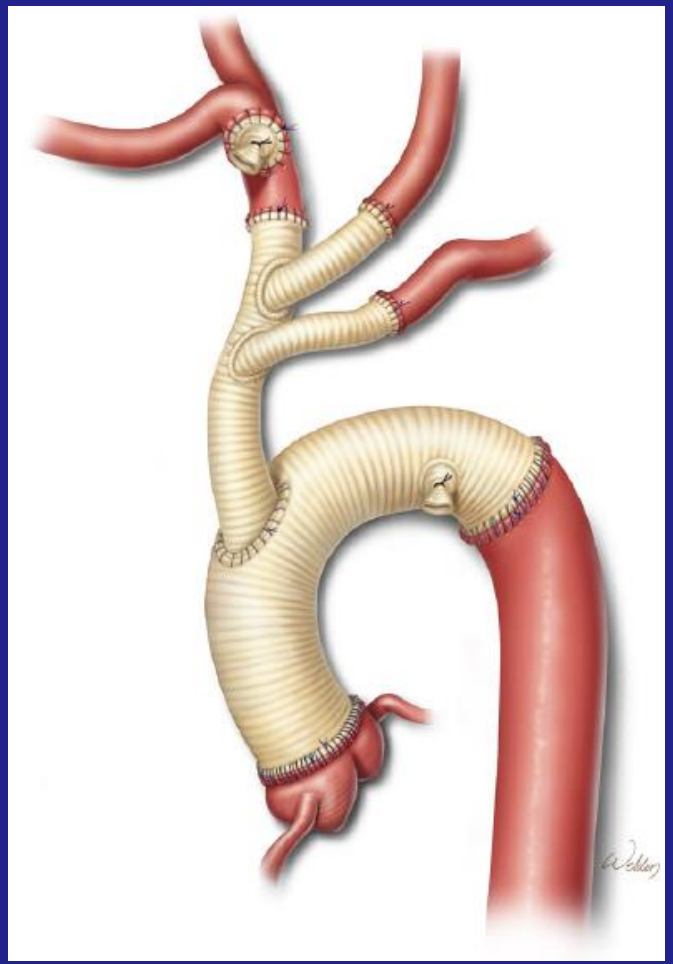
Conduit with valve

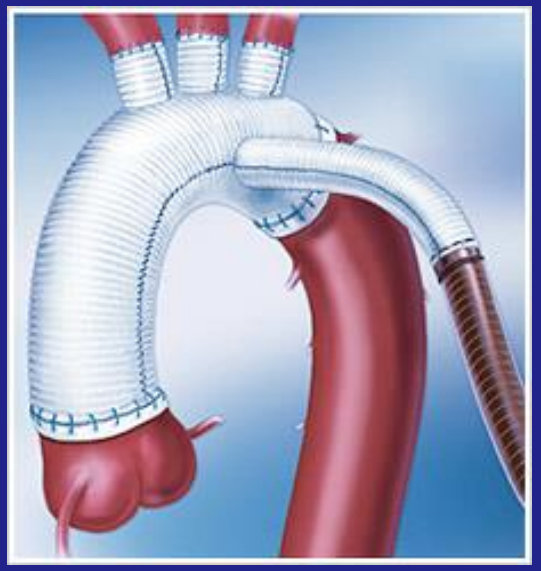
Valvular conduit with CABG in situ

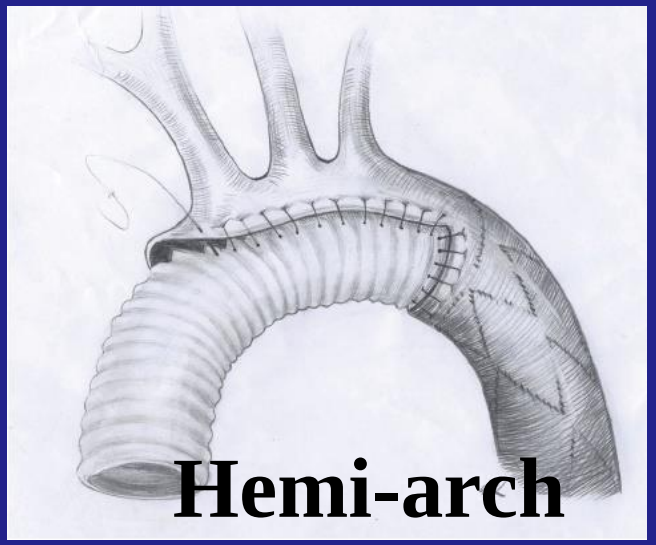


Prostheses – aortic arch

Total arch

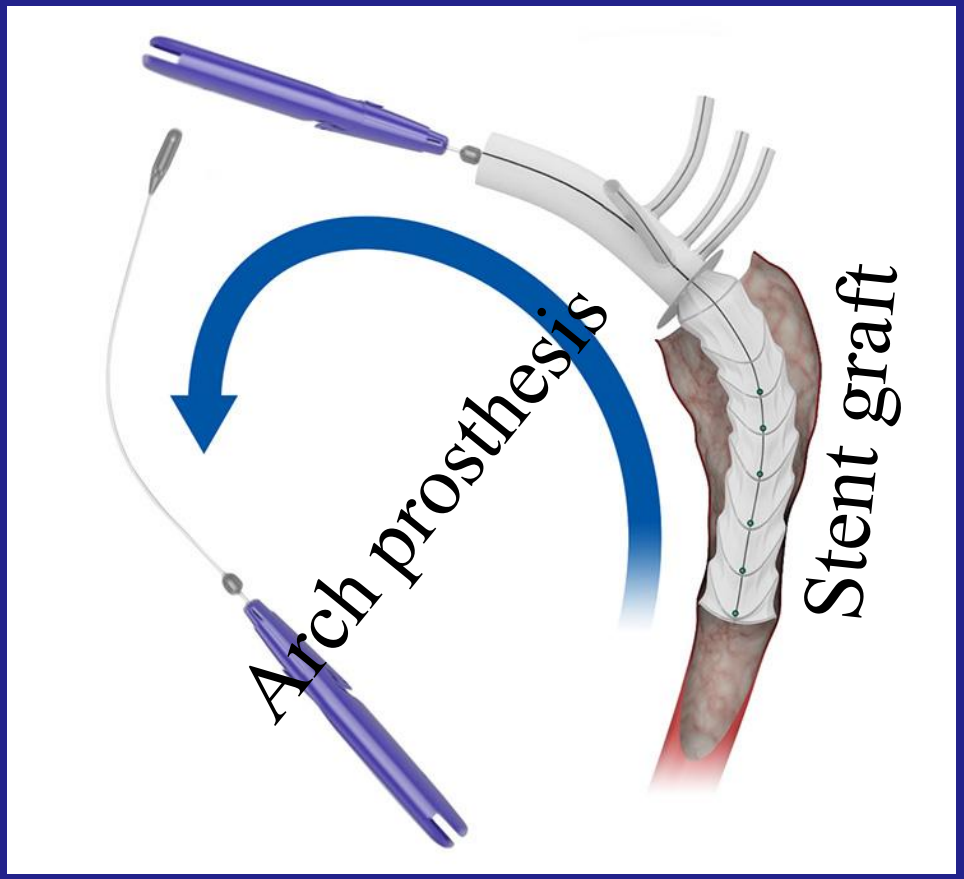


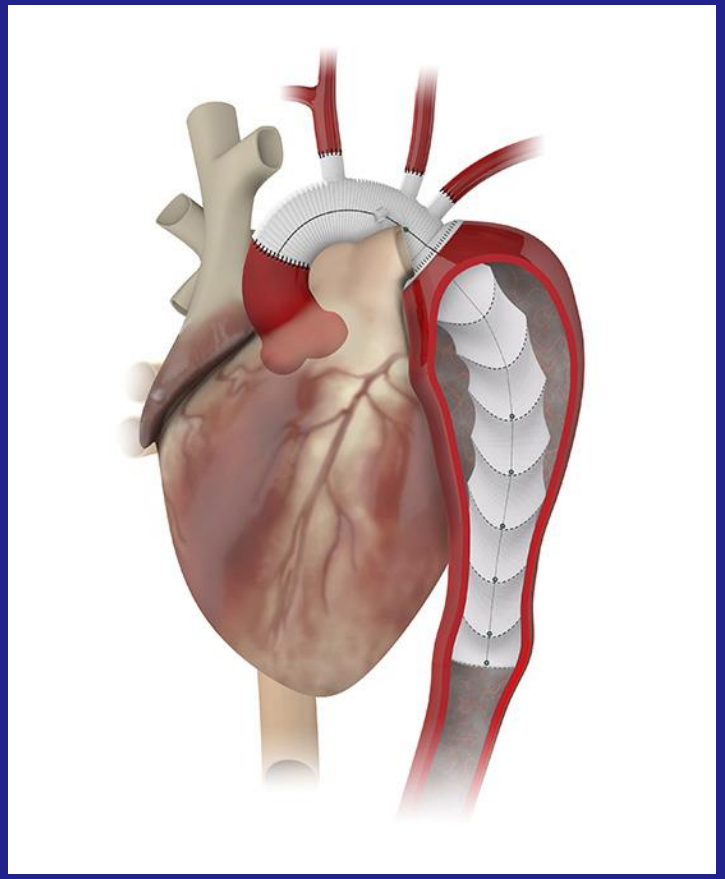




Hemi-arch

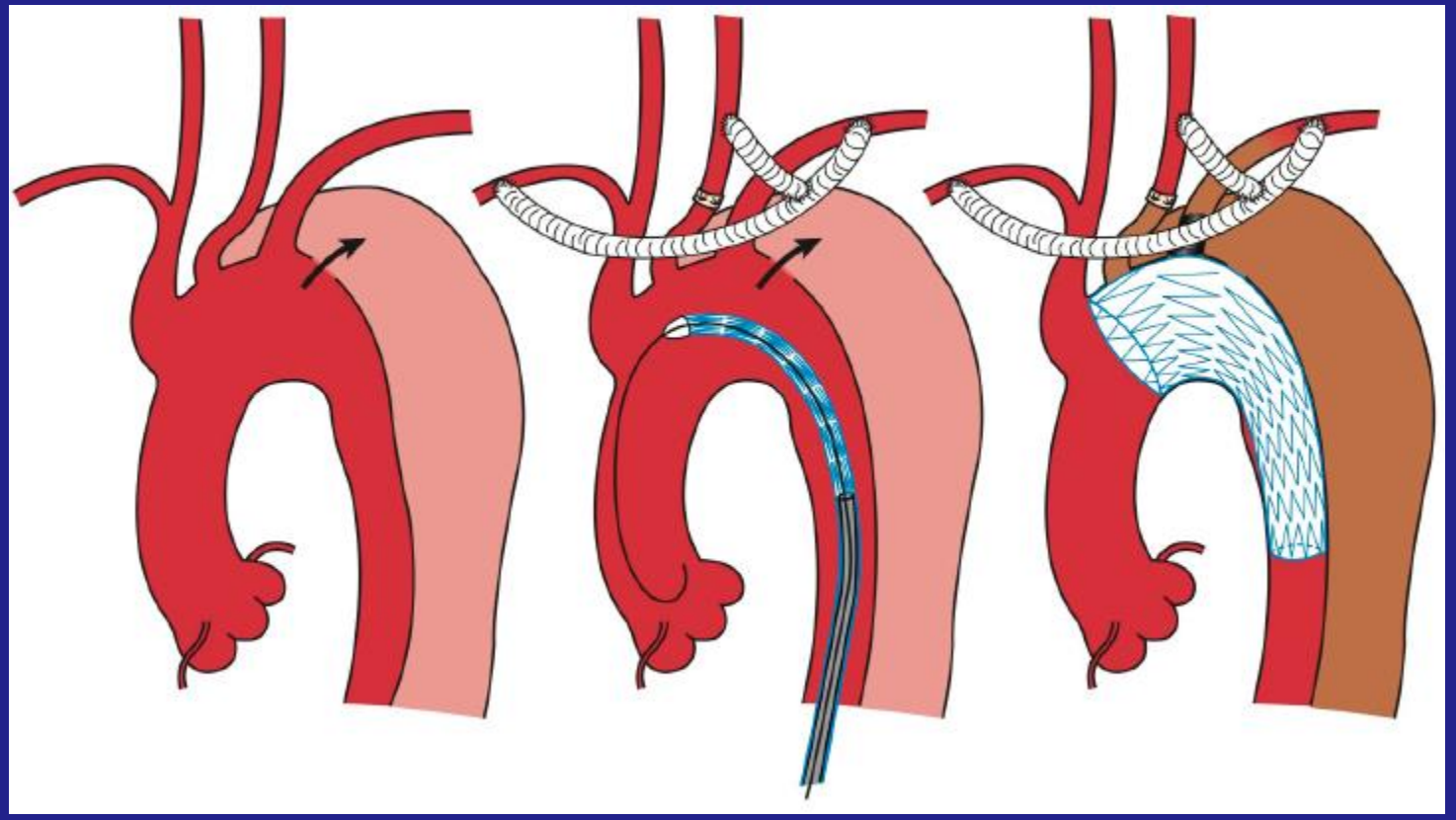
Prostheses – frozen elephant trunk



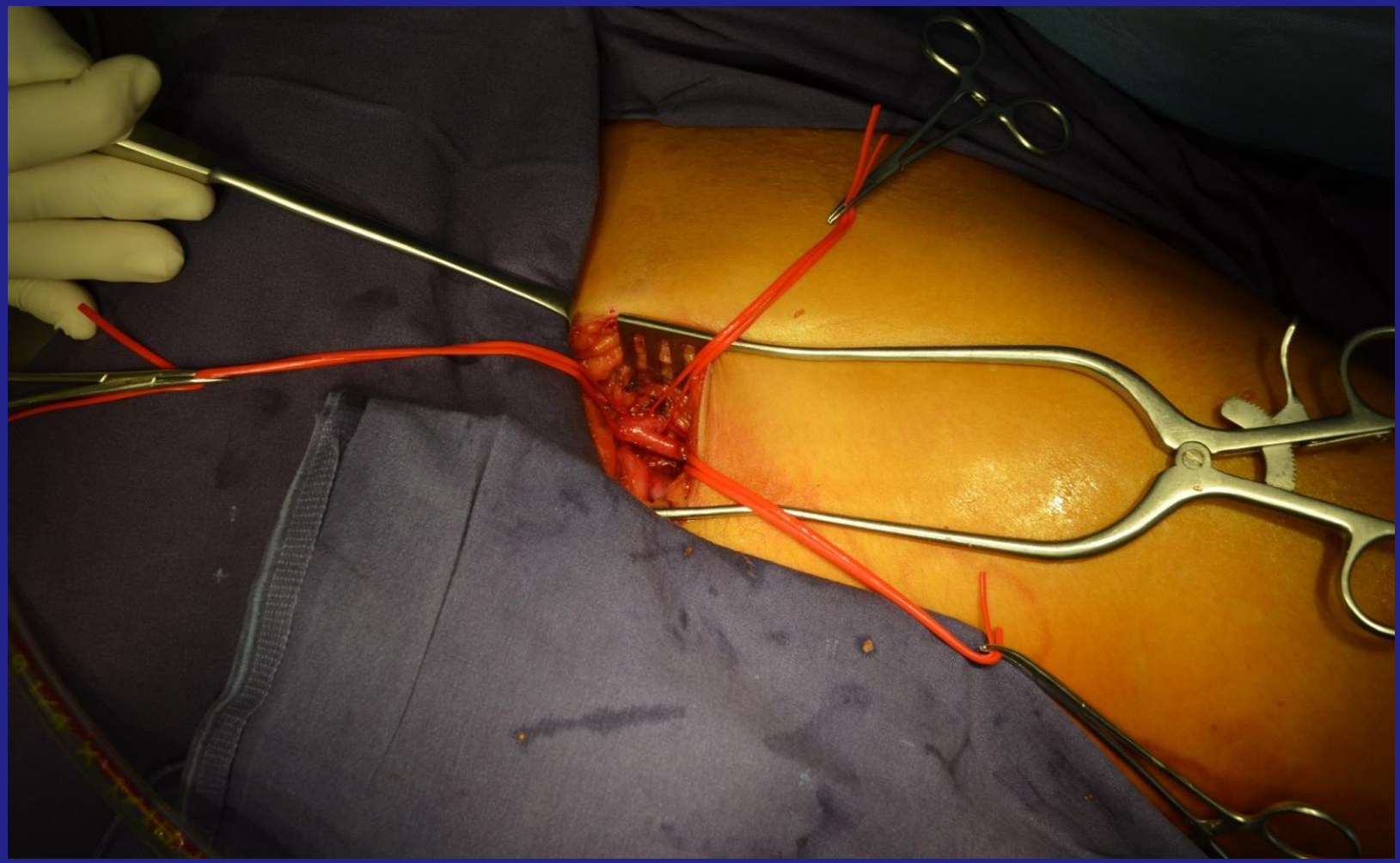


Stentgrafting (endovascular repair)

- Ascending: coronaries, valve, motion, aortic occlusion, brain damage (embolization, ischemia)
- Arch – crossover bypass (subclavian-carotid)

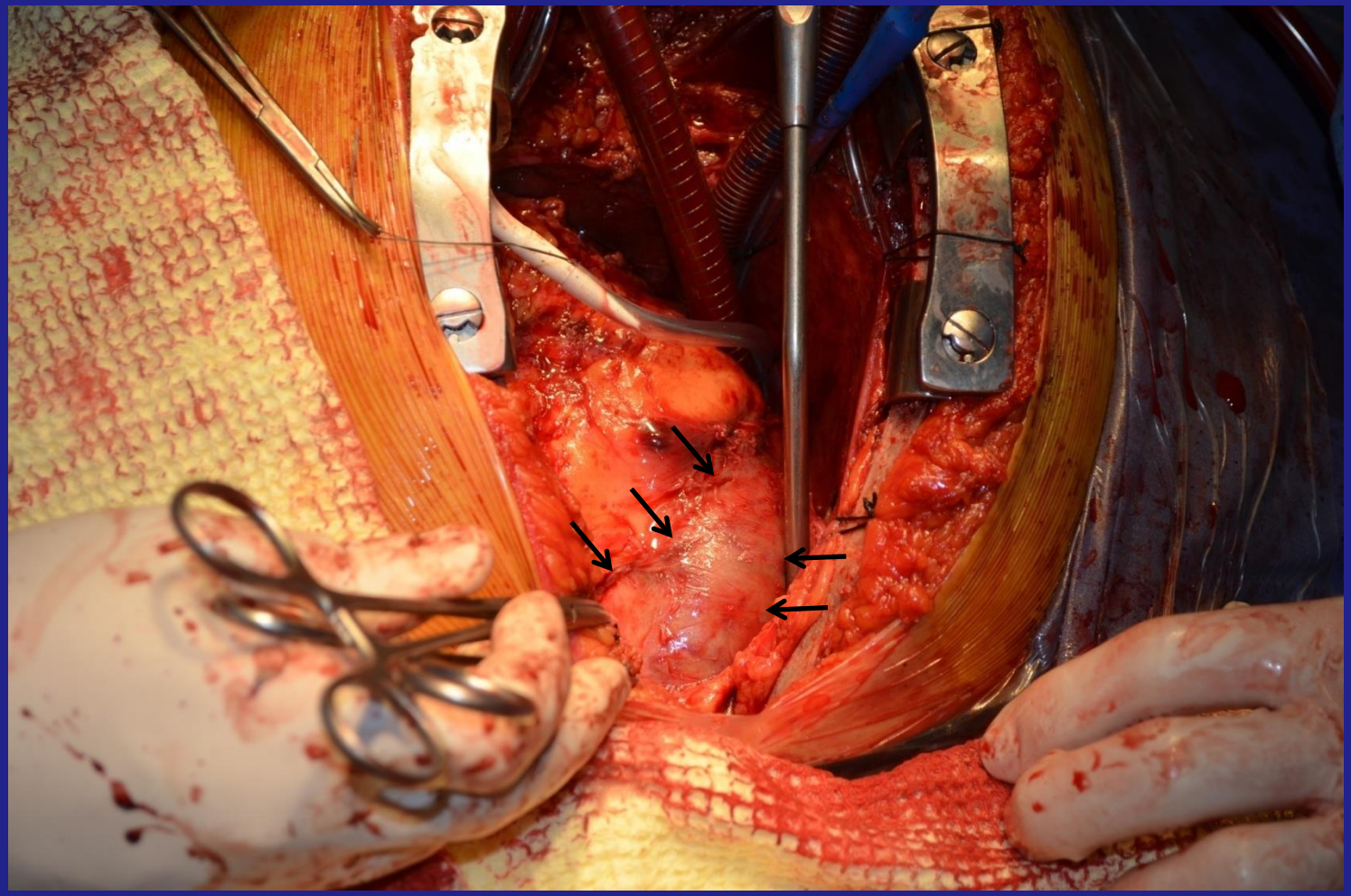


Exposing left femoral artery

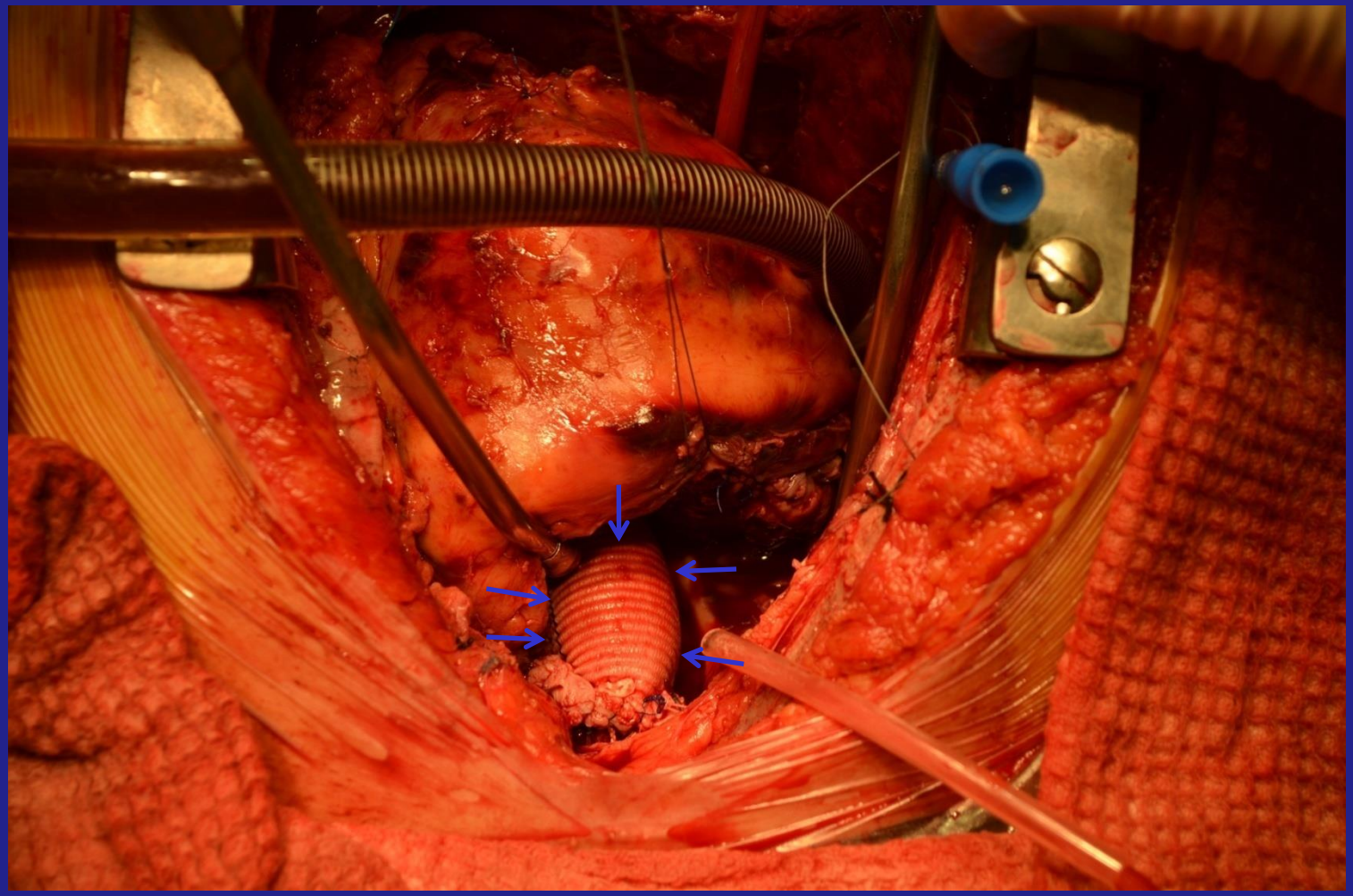


Femoral venous cannula

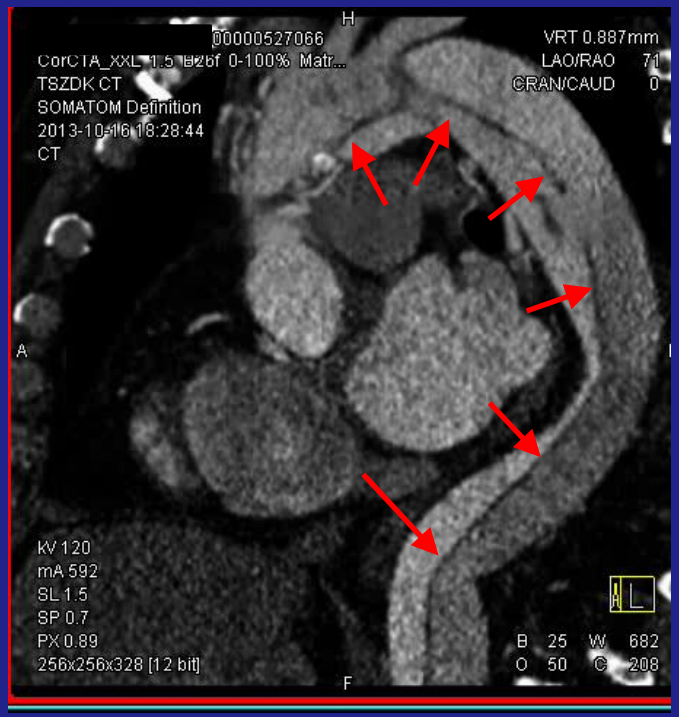
Chronic ascending dissection

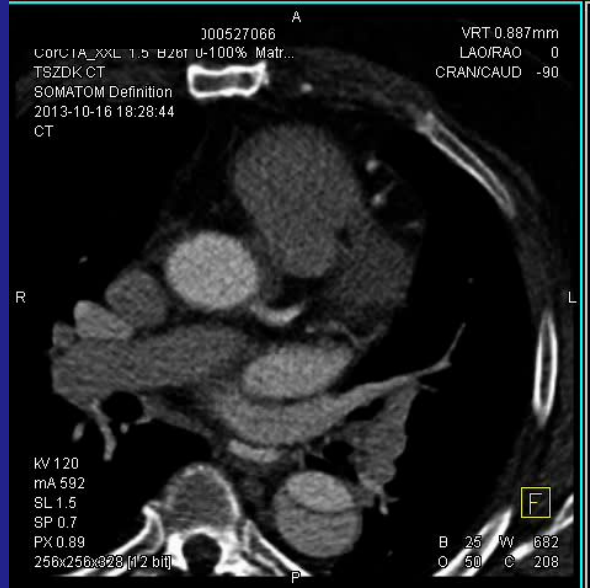


Ascending conduit in situ



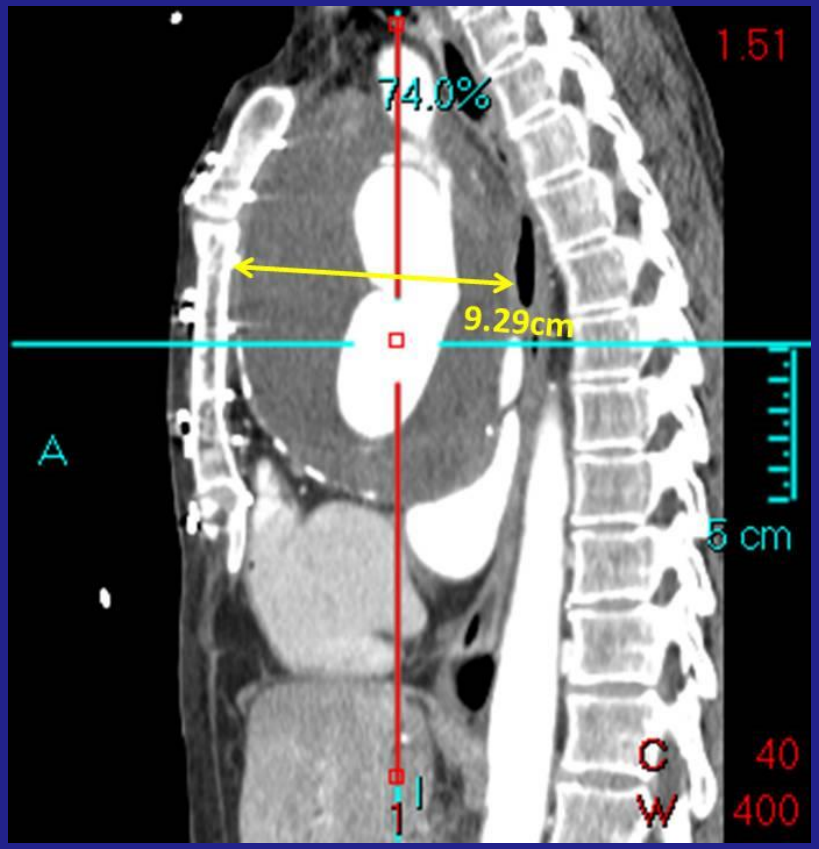
Residual arch and descending dissection after Bentall

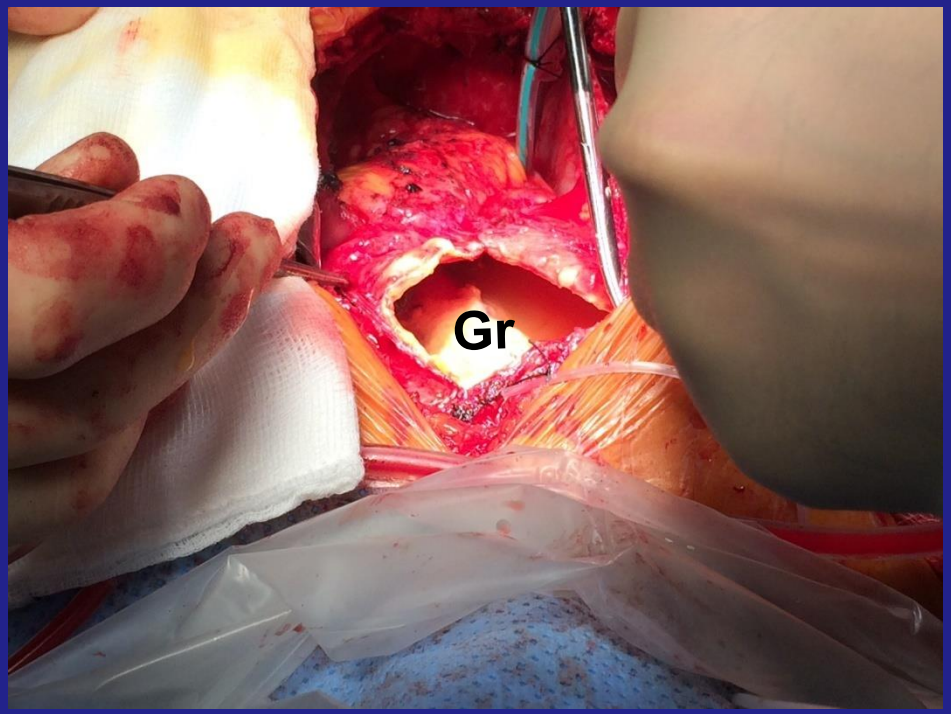




Thx to Dr. Sandor Szukits,
PTE Radiology

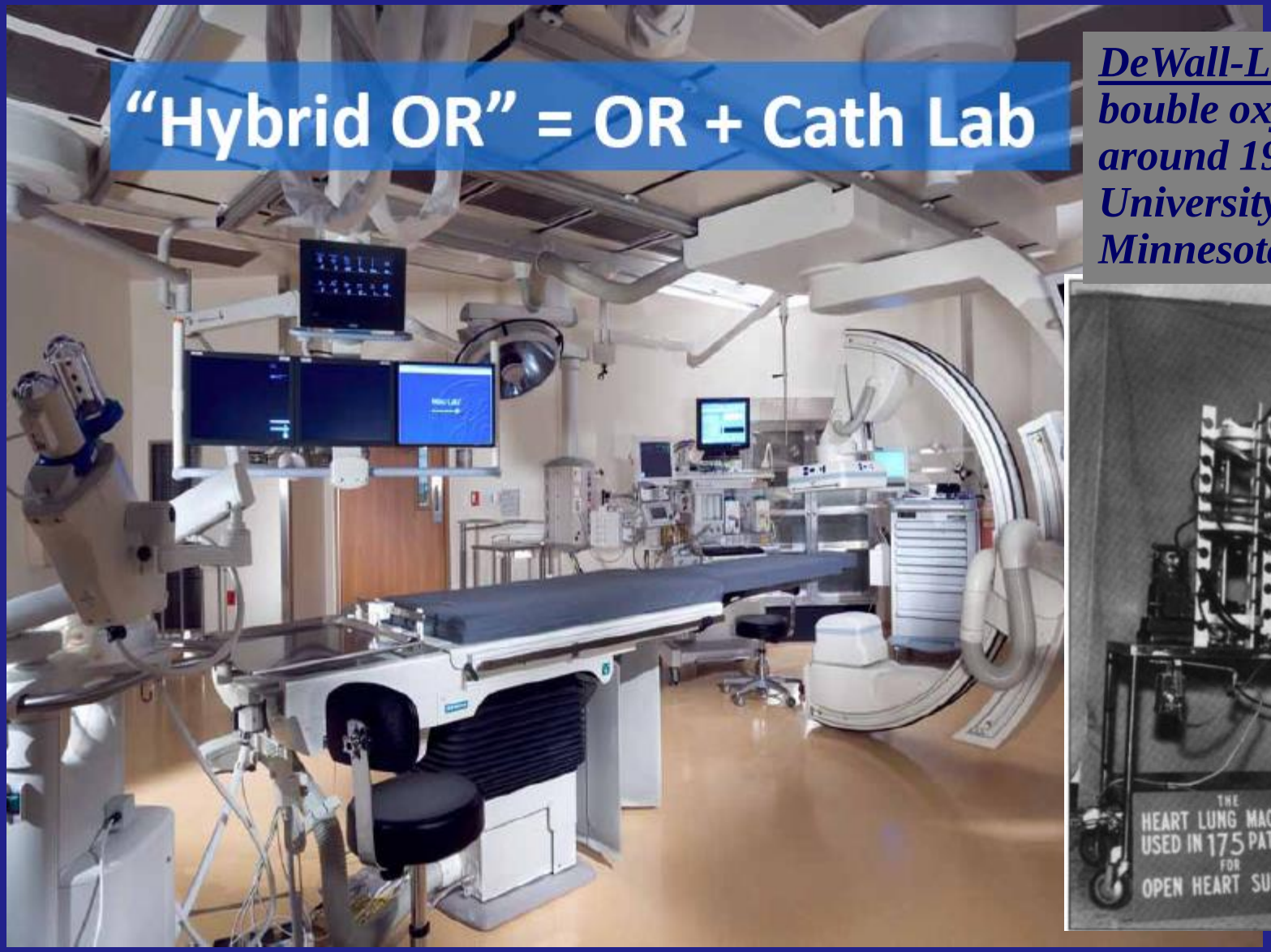
Giant perigraft seroma on ascending





Thx to Manoj Kuduvalli, MD
LHCH Liverpool, UK

Thank you for your attention !



DeWall-Lillehei bouble oxygenator around 1955-56, University of Minnesota